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JOURNAL OF PALEONTOLOGY, VOL. 12, NO. 6, PP. 537–569, PLS. 62–66, NOVEMBER, 1938

TAXONOMY OF MISSISSIPPIAN PRODUCTIDAE

A. H. SUTTON

ABSTRACT

Mississippian Productidae are classified in two subfamilies and 16 genera, containing 74 species and 2 varieties, which are listed with bibliography and synonomy. Principles of taxonomy are discussed. Separation into subfamilies is based on the shallow or deep character of the visceral cavity. Genera are based on external and internal characters, greater emphasis being placed, in general, on external features. All genera, but not species, are described. Each generic description is accompanied by sufficient figures to illustrate adequately all essential characters. Known occurrences of Mississippian genera in this country are shown in tabular form. An attempt is made to show the phylogeny of the family for Mississippian time. The status of the genus *Productus* is discussed.

The family Productidae is one of the most characteristic and dominant fossil groups of late Paleozoic time (Mississippian, Pennsylvanian, and Permian periods). Members of this family not only are among the most common brachiopods but are almost always present in rocks of these periods. Increased refinement in stratigraphic classification requires better and more precise definition of fossil genera and species. Because the Productidae include some of the most reliable stratigraphic markers in the late Paleozoic rocks in many areas, any improvement in their classification which will increase their value should be helpful. Any classification of the Productidae is attended with considerable difficulty. Most forms possess quite similar internal characters which renders their use of limited value for taxonomic purposes. The external features exhibit many examples of apparent gradation from one type to another, so that drawing sharp and precise lines of demarcation is a problem.

Acknowledgments.—In preparing this paper free use has been made of the literature. Most of the types of species described from this country have been studied. Authentically identified specimens of many foreign species have also been examined. Sincere thanks are expressed to Prof. Carey Croneis and other officials of Walker Museum of the University of Chicago, and to Drs. G. H. Girty and J. S. Williams of the United States Geological Survey for the opportunity of studying the many productid specimens, both types and others, in the collections at these institutions. Acknowledgment is also made of the many valuable suggestions and criticisms by Drs. Croneis and Williams and by Dr. H. W. Scott of the University of Illinois.

HISTORICAL REVIEW OF PRODUCTID CLASSIFICATION

In all of the early works on the Productidae, the genus *Productus* was made to include a great variety of forms and a large number of species. While it is true that the most aberrant forms were assigned rather early to other genera, still, until 1914, the majority of productid species were retained in *Productus*. Various schemes of classification were proposed in earlier years, notably by De Verneuil, De Koninck, Waagen, and Hall and Clarke. Most of these were essentially keys for grouping species rather than attempts to classify the various forms into genera.

In 1914 the publication of Ivor Thomas' monograph "The British Carboniferous Producti. I.—Genera *Pustula* and *Overtonia*" stimulated a renewed study of this important group of fossil brachiopods. In this publication Thomas gave an excellent summary of all previous literature dealing with the Productidae and suggested principles for a natural generic and specific classification. Since then,

this work has been continued by Chao (1927 and 1928), Fredericks (1928), Muir-Wood (1928 and 1930), Dunbar and Condra (1932), King (1930) Licharew (1936), and others.

Although the work of foreign contributors embraced Productidae of Lower and Upper Carboniferous, and Permian, no one has treated adequately all the productid species of these periods in this country. The nearest approach to a satisfactory treatment of all forms of any one period was made by Dunbar and Condra (1932) for the Pennsylvanian. King (1930) carried it on to a certain extent for the Permian forms, Stuart Weller (1914) for the Mississippian; and G. H. Girty (1908, 1910 and 1915-C,) has contributed importantly to the classification of the Productidae of all three of these geologic time units. Many other workers have, from time to time, added to the classification of these important fossil forms. Reference is made to these in the bibliography and synonomy. The very large amount of literature on the Productidae makes it impossible to refer specifically to each contribution here.

The purpose of this paper is to define the various Mississippian genera and arrange the previously described species of Productidae of this age in their proper genera. It is hoped that the collection into one paper of bibliographic references to all described Mississippian forms will enable future workers to make more rapid progress in their work. It is also hoped that the same scheme of classification may be applicable to Productidae of other geologic periods. It is possible that some papers in more or less obscure publications have been overlooked. Species are not redescribed and illustrated. To do so would increase this paper to monographic proportions and perhaps would not be justified because of the availability of other publications. Only enough figures are included to illustrate typical members of each genus properly. These illustrations have been made from photographs of type specimens.

PRINCIPLES OF PRODUCTID CLASSIFICATION

Volumes have been written on the characters of the Productidae. What is really needed is a classification by which the different forms may be recognized. Most of the confusion in the classification of Productidae has arisen because of the different views held by workers as to which characters of the shell constitute valid generic determinants and to the method of approach adopted. Thomas gave a critical review of previous attempts at classification prior to 1914 and separated several genera from *Productus*, some on external features and one on internal. He emphasized the importance of ontogenetic changes in determining a natural classification. Although he placed greatest reliance on surface features, he suggested that the general shell shape, i.e., thin or deep visceral cavity, was probably an important criterion in classification.

Fredericks (1915), who studied the Upper Carboniferous and Permian Productidae of Russia, had been working along the same line and proposed grouping all the species of Productidae into two major sections, one of which he subdivided, as follows:

A. Producti typica—shells not geniculate.
  a. Visceral chamber deep, brachial valve flat or gently concave.
  b. Visceral chamber thin, brachial valve curved to match the pedicle.
B. Producti proboscidei—shells with brachial valve geniculate, the visceral chamber being set off from the anterior trail.

Chao (1927, 1928) carried this line of investigation further and erected several new genera and subgenera. Muir-Wood (1928, 1930) and Dunbar and Condra (1932) followed the same method of approach, each being responsible for the introduction of new generic names. Chao especially urged that three distinct characters should be considered in classifying Productidae, as follows: (1) ***The shape of the two valves***, which determined the

shape of the cavity which was occupied by the soft parts of the animal. (2) *Surface sculpture;* in using this criterion he followed Thomas in emphasizing the importance of ontogenetic study. (3) *Internal structure,* which he regarded as of minor importance since most of the known forms possess internal features which are quite similar.

Muir-Wood's (1930) most recent and significant contribution was the restriction of the name *Productus* to a small group of Lower Carboniferous species characterized by a flange-like diaphragm around the margin of the visceral disc of the brachial valve, and the introduction of the name *Dictyoclostus* for the semireticulate forms which for many years have been considered as typifying the genus *Productus*. She also proposed the name *Eomarginifera* for late Mississippian (Lower Carboniferous) species which possess a marginal ridge around the visceral disc of the brachial valve, the feature on which the genus *Marginifera* was founded in 1884. Dunbar and Condra (1932) followed Muir-Wood in restricting *Productus* to the forms with the diaphragm and in using *Dictyoclostus* for the semireticulate types.

Licharew (1936) in his work on the Permian Productidae failed to follow the lead of Muir-Wood and Dunbar and Condra in restricting *Productus s.s.* to forms with a diaphragm. He retained in *Productus* 25 forms which he divided into 8 rather wide groups including forms that correspond to *Linoproductus*, *Thomasia*, *Plicatifera*, *Eomarginifera*, and *Marginifera*. He assigned subgeneric rank to *Striatifera* and *Pustula*. In the latter he placed forms which correspond to *Pustula*, *Krotovia*, *Echinoconchus*, *Juresania*, and *Waagenoconcha*. He also recognized as genera, *Avonia*, *Sinuatella*, *Urushtenia*, and *Marginifera*. Finally he proposed a new subgenus *Strophalosiina* under the genus *Strophalosia* and a new genus *Pectenoproductus* of the subfamily *Strophalosiinae*.

It is interesting to note that most of these workers, although they emphasized the shape of the valves as important in classification, did not always take special cognizance of that point in arranging the various forms in their schemes of classification.

PROPOSED TAXONOMY

I believe that the shape of the valves is the most significant character for productid classification and, on that basis, have placed all described Mississippian forms in two sections, Productellinae and Productinae, which are assigned subfamily rank (Fig. 1). It has been suggested that the depth of the visceral cavity may have been determined by the lateral extent of the shell, which was in turn determined by the living conditions. This postulates that shells which were broad in the posterior portion afforded enough room for the living animal without a deep visceral cavity, and assumes that the shape of the shell determined the body shape of the animal which occupied it. It seems more logical that the shell shape of any animal which was no more closely attached to the substratum than were most Productidae is a result of body shape rather than a cause, and that some shells possess a thin and others a deep cavity because the inherent body shape of the animal which occupied the shell determined the shape of the shell. The shell shape can hardly have been determined by environment, because shells with thin visceral cavity occur intimately associated with those possessing a deep cavity. The presence of a trail is not considered significant enough to warrant a distinct taxonomic unit, as has been given by some of the earlier workers. Trails have developed to a variable extent in different types of productid shells. This structure is here considered a gerontic feature.

A. A. Stoyanow (personal communication) has in manuscript a proposed classification of the Productidae in which he separates them into two major subdivisions on the character of the cardinal process, whether bifid or trifid. A very suggestive parallelism exists between

Stoyanow's classification and mine, for all of the genera (or subgenera) in Mississippian strata of this country which he places in the group characterized by a bifid process fall in my section characterized by a thin visceral cavity. Likewise all of those known from this country which he lists as possessing a trifid process go in the section with medium to deep cavity. Some genera, the cardinal process of which is not known, are assigned to each of my major subdivisions. Stoyanow lists several genera (or subgenera) which are not known from this country and some Pennsylvanian and Permian forms which are not considered in this paper.

Obviously, if this relationship of type of body cavity and cardinal process holds true for all forms among productids, it cannot be a mere coincidence. I have not studied the cardinal process of all of the generic types, but it may be said in general that studies so far made substantiate Stoyanow's conclusions. One notable exception is observed in the genus *Echinoconchus*, for in most specimens examined the process is a modified trifid form, though in some it appears bifid. The classification based primarily on shape of the

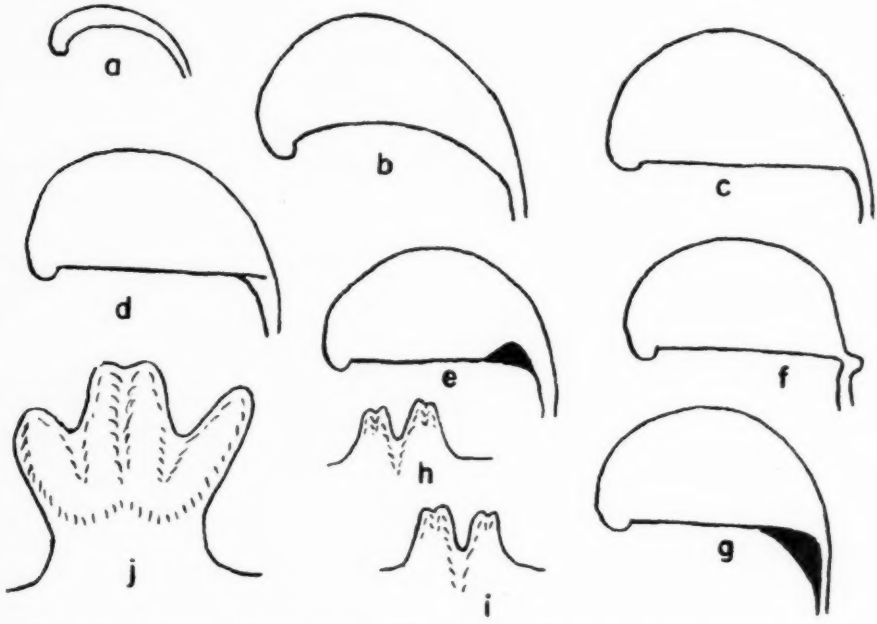

FIG. 1—Diagrammatic longitudinal sections showing features of the visceral cavity and sketches of the cardinal process in Productidae.

a, ***Productella***, showing the very thin visceral cavity that is characteristic of the Productellinae, greatest depth of cavity occurring in the umbonal region. *b*, *c*, ***Dictyoclostus***, showing deep visceral cavity that is characteristic of the Productinae, greatest depth of cavity occurring approximately at mid-length of the cavity. Similar features appear in *d–g*, representing genera that are distinguished by special characters of the shell at the border of the visceral cavity adjoining the trail. *d*, ***Productus***. *e*, ***Marginifera***. *f*, ***Marginicinctus***. *g*, ***Marginirugus***. *h*, *i*, Cardinal process of ***Productella pyxidata*** (Hall), viewed from outside and inside, respectively, showing a typical bifid process (camera lucida, ×10). *j*, Cardinal process of ***Dictyoclostus americanus*** (Swallow), viewed from inside, showing a typical trifid process (camera lucida, ×10).

body cavity is preferred because this is a character recognizable in most specimens, whereas the number of specimens in which the cardinal process may be observed is relatively small. If the cardinal process were made the chief basis of classification it still would be necessary in most instances to correlate the different types of processes with other features in order to be certain of identification.

Genera of the two major subdivisions are based on external or internal features, or both, and forms which may possess quite similar sculpture are placed in different subfamilies and genera if the shape of the visceral cavity is different. I believe that this accords with valid principles of taxonomy because two forms differing greatly in body shape undoubtedly belong to different phylogenetic series even though surface sculpture may be nearly the same. In classifying these brachiopods on the depth of the visceral cavity one must be certain that the curvature of the brachial valve is not a function of preservation, for in many specimens this valve has been crushed toward the pedicle valve.

In erecting the following classification difficulty has been encountered in some instances because of certain forms which appear to represent gradations between two rather distinct types. The number of such cases, however, is probably no greater than might be expected in the classification of any group of fossil forms as large as the Productidae. These are the forms for which some students would employ the taxonomic rank of subgenus. This might be a proper solution of the problem, and possibly better than the one here followed in assigning them to definite genera. Undoubtedly there will always be questions of this kind which will not be answered satisfactorily for all.

The features which have been made the basis of generic classification include the following: (1) spines, (2) radial markings, (3) concentric markings, (4) marginal rings and cinctures, (5) internal characters, (6) cardinal features, and (7) trails. Variations in these characters give basis for specific classification.

Spines.—Productid spines are slender tubes which rise from the outer shell layers. They are of two types, erect and oblique, and do not occur commonly on the same individual. The erect spines rise at a high, but not necessarily a right angle, from the shell surface and may be relatively long. They are normally confined to the pedicle valve, either scattered more or less irregularly over the shell surface, or restricted to more or less definite parts of the shell, such as a row along the cardinal margin, groups on the ears, or rows extending obliquely from the beak to the lateral margins along the lines of separation of the umbonal slopes and ears. In some forms the erect spines were possibly attached to external objects or helped give support to individuals that were not firmly attached. The oblique spines are relatively short and lie close to the shell surface. They occur on both valves and are usually closely spaced. In several forms these spines are arranged in a row or rows on more or less well defined concentric bands.

Radial markings.—Radial markings consist of costae, fold and sinus. Great variation exists in the costate ornamentation of productid shells. Some forms possess very fine, often flexuous costae that are almost fine enough to be designated as striae. In others the markings are much coarser. In some genera the shell is costate throughout, in others it may be without costae in early stages and costate in later, or costate in early stages and smooth, pustulose, or spiny in later stages. Some forms possess a sinus in the pedicle valve and a fold in the brachial. Other forms have neither.

Concentric markings.—Concentric markings consist of growth lines, rugae, and bands. The rugae are the concentric folds or wrinkles on the shell. The physiological cause of these, if there be one, is not known. Several workers (Thomas, 1914, p. 233; Muir-Wood, 1928, p. 14; Chao, 1928, p. 41) have speculated on this point without reaching any very

definite conclusion. The rugae possess a somewhat asymmetrical section, the steeper slope commonly facing the posterior edge of the shell. Rugae of the brachial valve are usually narrower than those of the pedicle valve, and they are commonly more symmetrical and distinct on the brachial valve. The rugae may extend across the entire shell, or be more or less confined to the ears and umbonal slopes. They are usually restricted to the visceral disc and often to the posterior portion of it.

In several genera the concentric markings are more or less well defined bands with a steep anterior and more gentle posterior slope. These bands are commonly more prominent on the brachial than on the pedicle valve. Each band of *Pustula* bears a single row of oblique spines; in *Echinoconchus* there is more than one row of spines on each band. Forms possessing concentric bands usually have them over the entire shell, although they are often absent in the umbonal region. Shells that bear both rugae and costae show a well reticulated surface in the portion of the shell where these occur together.

Marginal rings and cinctures.—Some forms develop a ledge or ringlike structure around the lateral and anterior margins of the visceral portion of the pedicle valve. This ledge is usually separated from the trail by a cincture or narrow incision in the pedicle valve, as seen in the cincture of the pedicle valve opposite the marginal diaphragm in the brachial valve of *Productus* (*Diaphragmus* of Girty). The ring or ledge is an integral part of the shell. It has been made the basis for differentiation of a new genus, *Marginicinctus*.

Internal characters.—The internal features of productid shells are commonly quite similar. The general internal characters have been well discussed by many workers. In the pedicle valve there are two well marked dendritic and flabellate diductor muscle scars, between which are two narrow, elongated adductor impressions. Two more or less circular hollows occur, one on each side of the central line and slightly anterior to the diductor scars.

The brachial valve contains the cardinal process, which varies from erect and strong to small and weak. Processes may be considered as bifid or trifid, although considerable variation occurs in each type. Bifid processes often possess an incision in each lobe, which produces a tetralobate appearance and is probably the type of process which has been described as tetralobate. The clefts in the lobes of a normal bifid process do not extend as deeply as the central incision. The trifid process may have developed from the bifid by increase in the depth of incision in the lobes and decrease of the cleft between the lobes. Some forms which appear tetralobate when viewed from one side may appear trilobate from the other, the inner margins of the two primary lobes having joined. The normal trifid process usually contains a median depression in the central lobe. Considerable variation exists in the character of the process even among species of the same genus. This problem needs further study. Fig. 1*h–j* illustrates typical bifid and trifid processes.

The base of the process is extended anteriorly in a median ridge, which ends near the center of the visceral disc, where it is usually compressed laterally and elevated. Dendritic adductor scars occur on each side of the median ridge. From each adductor scar a band extends outward, then forward, and finally curves inward and backward. These bands are probably the traces of the brachial ridges. All these internal features vary somewhat in different genera, among species of the same genus, and probably among individuals of the same species.

In addition to the internal features mentioned, certain genera possess special characters such as the diaphragm in *Productus*, the marginal ridge of the brachial valve in *Marginifera*, and the rugose thickening of the brachial valve, anterior to the place of abrupt bending, in *Marginirugus* n. gen. As noted above, the pedi-

cle valve of *Productus* possesses a cincture or incision opposite the diaphragm of the brachial valve.

Cardinal features.—Some forms possess a narrow cardinal area. This is a constant feature of *Productella*, *Leptalosia*, and *Strophalosia*. The cardinal area occurs on both valves of *Strophalosia* and *Productella* but is confined to the pedicle valve of *Leptalosia*. Some later forms of Pennsylvanian and Permian age show a narrow area, although the Mississippian ancestors did not. The presence of a cardinal area among productids probably does not have more than specific value, except for the genera noted above and probably one or two foreign forms. In many instances it may not be even of specific value. Cardinal teeth and sockets are associated with the cardinal area in members of the three above mentioned genera, although teeth are probably lacking in post-Mississippian species of *Leptalosia*, according to Dunbar and Condra (1932, p. 260).

Trails.—The trail or jabot is a common feature of those productid shells which possess a deep visceral cavity, although not all members have a trail. The trail is the extension of the valves parallel to each other beyond the point of geniculation or abrupt curvature of the shell. In some forms the trail portion tends to form more or less cylindrical prolongations. These are the Proboscidei of Fredericks.

A number of conclusions may be drawn with respect to the relationship between general shell shape and certain shell characters or between certain external features, as follows:

(1) Bifid cardinal processes are associated with thin visceral cavities, and trifid processes with medium to deep cavities. This association needs further study. There may be exceptions.

(2) Erect spines are usually confined to the pedicle valve. There are a few exceptions to this general rule.

(3) Oblique spines always occur on both valves.

(4) Shells with deep visceral cavity may possess either type of spines. Many of these possess rugae.

(5) Shells characterized by concentric bands are often smooth in the umbonal region. The bands are equipped with oblique spines.

(6) Trails usually occur on shells which are marked by rugae in youth.

(7) Shells which are marked by rugae often possess a median sinus and fold, although these may occur on unwrinkled forms.

Whether any real genetic relationship may or may not be implied by all of these associations can not be said. Such associations, however, may be of value in identification or classification.

STATUS OF THE GENUS PRODUCTUS

The greatest problem in any classification of the Productidae hinges on the proper disposition of *Productus s.s.* At present there are two rather distinct factions among paleontologists. One group holds that the Law of Priority should be strictly applied and that this generic name should be restricted to a very limited number of Mississippian (Lower Carboniferous) species which are characterized by the shelly plate or diaphragm such as occurs in *Anomites productus* Martin, the genotype of *Productus* as determined by Muir-Wood (1930, p. 101). The other group feels that the long established usage (123 years) of this name for those forms which are characterized by a reticulated posterior portion of the shell is sufficient basis for retaining the name for these forms, because this is the kind of shell most people know as *Productus*, and the type which includes the most characteristic Productidae. Some workers favor the use of subgeneric appellations for the several rather distinct types among the semireticulate forms. Another faction of the latter group feels that it is more appropriate to designate the forms typified by *P. semireticulatus* as *Productus*, and that other forms, if distinct from the *P. semireticulatus* type because of some special character, should be considered worthy of full

generic rank. I favor a generic status for all these forms. The question of generic versus subgeneric rank, however, is largely a matter of personal opinion in most cases, and has no vital bearing on the matter. In order to clarify the situation, a brief history of the evolution of the name *Productus* is given.

The genus *Productus* was proposed by J. Sowerby (1814, p. 153). In his description he designated the genotype as follows:

> His (Martin's) Conch. *Anomites productus* is a good type of the genus, therefore, as the name *Anomites* must be laid aside, I have adopted his specific name as the generic one, the character it expresses being also peculiar.

On a later page (p. 158) he renamed *Anomites productus* Martin, *Productus martini*. The generic description given was as follows:

> An equilateral unequal-valve with a reflexed, more or less cylindrical margin; hinge transverse, linear: beak imperforate; one valve convex, the other flat, or concave externally.

Later he described *Productus martini* (1821, p. 15) and cited *Anomites productus* Martin as a synonym. The description was as follows:

> Semicylindrical, convex above, with a flattened front, deeply striated, spinose; lesser valve nearly flat, deeply inserted; hinge line equal to the width of the shell.

His description was accompanied by three figures of probably three distinct species. Only one of the three figures appears to be identical with the form known as *Anomites productus* Martin, which was later designated *Productus productus* by Thomas. Another of the forms illustrated was a shell which appears to resemble *P. semireticulatus* (Martin). Although Sowerby's description does not seem to apply with absolute definiteness in all parts to either of the types illustrated, his discussion of the figures leaves little doubt but that he considered the form which later came to be called *P. productus* as the true type of the genus *Productus*. However there is some slight doubt because he did designate one of the remaining forms, a cast in sandstone, as *P. martini*. The illustration is suggestive of the *P. semireticulatus* type, especially the prominent auriculations and the extended hinge line, a feature stressed in the specific definition. The third illustration is of a large specimen which he described as follows:

> Fig. 3 is from a large, very concave, specimen, somewhat corrugated, and thus intermediate between *P. martini* and the following (*P. antiquatus*).

Consequently, it can be eliminated from consideration. Although it would seem that *P. productus* was the one which Sowerby considered as the type, it is nevertheless true that to a certain extent a question of interpretation is involved.

For many years *P. martini* was regarded as identical with *P. semireticulatus*, or a variety of it. DeKoninck and Davidson initiated this interpretation of the genus and were followed by others. Dall (1877, p. 58) gave *P. martini* Sowerby = *Anomites semireticulatus* Martin + *A. productus* Martin as the genotype of *Productus*. Hall (1893, p. 325) quoted *P. martini* Sowerby = *Anomites productus* Martin = *A. semireticulatus* Martin = *Productus semireticulatus* as the genotype. Hall and Clarke (1894, p. 297) reduced the genotype designation to *P. semireticulatus*. This designation was accepted until Thomas (1914, p. 238) identified *P. productus* as the genotype. Chao (1927, p. 26) and Muir-Wood (1928, p. 35) accepted Thomas' designation although they still included the semireticulate types in the genus.

Meanwhile, Girty (1910, p. 217) defined a new subgenus, *Diaphragmus*, on the basis of a shelly plate or diaphragm around the visceral disc of the brachial valve, and later (1915, p. 50) elevated it to generic rank. Muir-Wood (1930, p. 101) reported the discovery of a similar structure in *P. productus*, as follows:

> Investigation of the species *P. productus* (= *P. martini* pars) has shown that it differs in internal structure from *P. semireticulatus* in having an extra shelly plate or diaphragm, which is developed round the anterior end of

the visceral disc of the brachial valve and extends between the trails of the two valves, usually at right angles to them.

Because of this discovery she placed *Diaphragmus* in synonomy and restricted the name *Productus* to a small group of Mississippian (Lower Carboniferous) species, which is in accordance with the Law of Priority, and introduced a new name, *Dictyoclostus* for the semireticulate type.

In order to avoid misunderstanding I have studied Martin's (1809, p. 9, pl. 22, figs. 1–3) original description and illustrations of his *Conchyolithus Anomites* (*productus*). The form described and illustrated is clearly of the *Productus productus* (*Diaphragmus*) type. Martin described it in part as follows:

> Its most striking characteristic is the lengthened cylindric form of the convex valve—This is always filled with limestone, which entirely conceals from observation the other part of the shell, as long as the specimen remains whole. With the slightest blow from a hammer, however, it constantly divides, *where the edge of the smaller valve rests against the inside of the elongated, cylindric part of the larger valve;* generally about half an inch or less, from the top of the shell.

This description fits very well Girty's genus, *Diaphragmus*, which almost always breaks along the plane of dehiscence in the pedicle valve opposite the diaphragm of the brachial valve.

Because Muir-Wood was correct in her selection of the intended type of the genus then, in strict accordance with the Law of Priority, the form with the diaphragm must be considered as the genotype, and *Productus* is applicable as a generic name only to a small number of Mississippian (Lower Carboniferous) species. Because of the known desire of several paleontologists to retain *Productus* for the semireticulate forms, I have endeavored to ascertain the judgment of American paleontologists as to the wisdom of requesting the International Commission on Zoological Nomenclature to suspend the Rules and establish *Productus semireticulatus* as the genotype of *Productus*.

The result of a canvass shows that opinion is about evenly divided. Several who are favorable to suspension feel that it is probably too late to accomplish this. Most of those who favor suspension wish to continue use of *Productus* for the semireticulate productids because these are considered the most characteristic members of the family and because *Productus* has such widespread descriptive as well as paleontological usage. Many who oppose suspension of the Rules do not like to see long-established usage overturned, but conclude that suspension is no more justified in this case than in many other similar cases. Some feel that suspension might perhaps have been requested advantageously in 1930 but that it is now too late, emphasizing the fact that a considerable amount of literature using the term *Dictyoclostus* has already been published and that to discontinue this name would result in added confusion.

Lack of agreement among American paleontologists probably corresponds to the attitude of workers in other countries and indicates that an attempt to secure suspension of the Rules at this late date is not desirable. It seems that the only basis on which anything like unanimity of agreement can be approached is strict application of the Law of Priority. On that basis *Productus* designates the forms with a diaphragm, *Diaphragmus* becomes a synonym of *Productus*, and *Dictyoclostus* includes the semireticulate forms typified by *Productus semireticulatus*. This may lead to temporary confusion but will result in ultimate clarification. It is unfortunate that the most characteristic biologic type of the family is not the most characteristic nomenclatural form, but difficulties encountered by the use of *Productus* as a descriptive term can be obviated by using *productid* in the sense in which *Productus* is now commonly used.

Classification of Mississippian (Lower Carboniferous) genera of Productidae is indicated in the accompanying Key to Genera. An attempt has been made also to show the phylogeny, geographic occurrence, and known geological range of the various genera of Mississippian Productidae (Fig. 3 and Table 1).

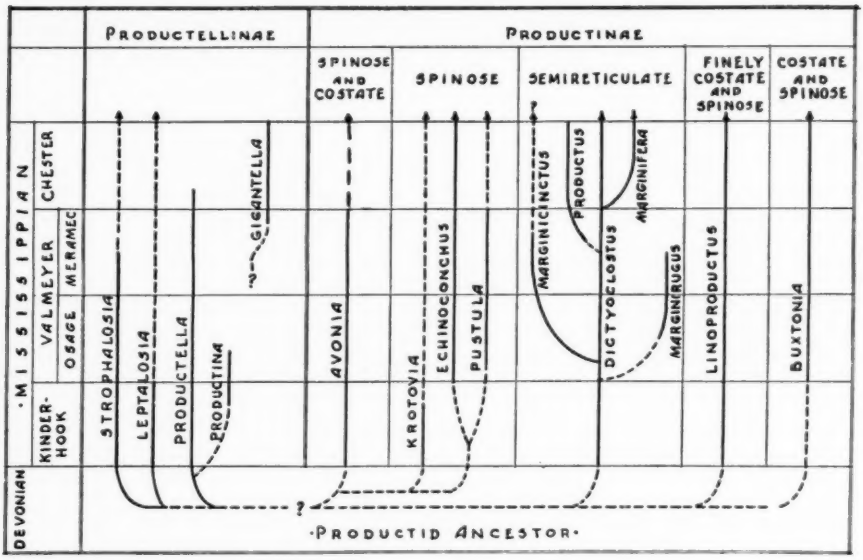

FIG. 2.—Phylogeny of Mississippi Productidae. Solid lines show known range. Arrows indicate genera known to continue into younger strata.

TABLE 1.—KNOWN OCCURRENCE OF MISSISSIPPIAN PRODUCTID GENERA.

Region and Stratigraphic Division		Leptalosia	Strophalosia	Productella	Productina	Gigantella	Pustula	Echinoconchus	Krotovia	Linoproductus	Productus	Marginirugus	Marginifera	Marginicinctus	Dictyoclostus	Buxtonia	Avonia
Mississippi Valley	U. Chester	—	—	—	—	—	—	x	—	x	x	—	—	—	x	x	—
	M. Chester	—	—	—	—	—	—	x?	—	x	x	—	—	—	x	x	—
	L. Chester	—	—	—	—	—	—	x	—	x	x	—	—	—	x	x	—
	Ste. Genevieve	—	—	—	—	—	—	x	—	x	x	—	—	—	x	x	x
	St. Louis	—	—	—	—	—	—	x	—	x	x	—	—	x	x	x	x
	Salem	—	—	—	—	—	—	x	—	x	—	—	—	—	x	x	x
	Warsaw	—	x	—	—	—	—	x	—	x	—	x	—	—	x	x	x
	Keokuk	x	—	—	—	—	—	x	—	x	—	x	—	x	x	x	x
	Burlington	—	—	—	x	—	x	x	—	x	—	—	—	—	x	x	x
	Fern Glen	—	—	—	x	—	—	—	—	x	—	—	—	—	x	—	x
	Kinderhook	x	x	x	x	—	x	—	x	x	—	—	—	—	x	—	x
Ouachita-Arbuckle Region	Pitkin	—	—	—	—	—	—	x	—	x	x	—	—	—	—	x	—
	Fayetteville	—	—	x	—	—	—	—	—	x	x	—	x	—	x	x	—
	Batesville	—	—	x	—	—	—	x	—	x	x	—	x	—	x	x	—
	Moorefield	—	—	x	—	—	x	x	—	x	x	—	—	—	x	x	x
	Boone	—	—	x	x	—	—	x	—	x	—	—	—	x	x	—	x
	Chattanooga	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Sylamore	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Rocky Mountains	Paradise[1]	—	—	—	—	—	—	x	—	x	x	—	x	—	x	x	—
	Brazer[1]	—	—	—	—	x	—	x	—	x	x	—	—	—	x	x	—
	Big Snowy[1]	—	—	—	—	—	—	x	—	x	—	—	—	—	—	—	x
	Madison	—	—	x	x?	—	x	—	—	x	—	—	—	—	x	x	x

[1] The Paradise, Brazer, and Big Snowy formations are approximately equivalent in age; they are younger than the Madison limestone.

KEY TO THE GENERA OF MISSISSIPPIAN PRODUCTIDAE

I—Subfamily PRODUCTELLINAE. Productids characterized by a thin visceral cavity, with the curvature of the brachial valve following closely that of the pedicle valve.

A—Shells attached to the substratum or other objects.

1—Minute forms adnate, attached by a large portion of the pedicle valve to other objects. Visceral cavity very thin. Only pedicle valve spinose.... ..... *Leptalosia*

2—Shells cemented by pedicle umbo, sometimes free in mature stage. Both valves may be spinose..... *Strophalosia*

B—Shells free or loosely anchored by spines.

1—Shells ornamented with costae, or costae and spines.

a—Shells with scattered spines, more or less irregularly arranged spines, and possessing cardinal features. Costae only slightly developed.... ..... *Productella*

b—Shells costate in all stages and with few scattered spines... *Productina*

2—Shells large and finely costate or lirate throughout growth, without reticulate ornamentation, although irregular wrinkles may occur on the ears and up the umbonal slopes..... *Gigantella*

II—Subfamily PRODUCTINAE. Productids with large and deep to medium visceral cavity. Pedicle valve convex, brachial flat or slightly concave. Shell free, loosely anchored by spines, or attached by a small area of the pedicle valve.

A—Shells ornamented essentially with oblique spines.

1—Spines arranged on concentric bands.

a—Spines of one rank on each band..... *Pustula*

b—Spines of two ranks on each band, one fine, the other coarse..... ..... *Echinoconchus*

2—Numerous spines thickly and irregularly arranged..... *Krotovia*

B—Shells finely costate or lirate throughout growth. Irregular wrinkles, rugae, usually present on the ears and extending up the umbonal slopes, scattered spines..... *Linoproductus*

C—Shells costate with reticulate umbones. Brachial valve usually geniculate. Spines restricted to pedicle valve.

1—A flangelike diaphragm present around the margin of the brachial valve. Rugae not prominent. Hinge line relatively short..... *Productus*

2—A conspicuous rugose, thickened lateral margin present on the brachial valve. Hinge line long..... *Marginirugus*

3—An elevated ridge occurring around the margin of the brachial disc. Hinge line relatively long..... *Marginifera*

4—A conspicuous ringlike border occurring around the pedicle valve at its line of contact with the brachial valve. Hinge line relatively short..... ..... *Marginicinctus*

5—Diaphragm, marginal ridge or ring lacking. Surface with continuous radial costae. Hinge line relatively long..... *Dictyoclostus*

D—Shells with costae developed at an early stage. Scattered spines with bases forming elongate nodes on costae. Anterior margin of pedicle valve often with a conspicuous spinose ornamentation and relatively free from costae. Umbonal region more or less reticulate..... *Buxtonia*

E—Shells spinose in early stage, developing costae after attaining considerable size..... *Avonia*

SYSTEMATIC DESCRIPTIONS

Class BRACHIOPODA Dumeril
Order PROTREMATA Beecher
Superfamily STROPHOMENACEA Schuchert
Family PRODUCTIDAE Gray
Subfamily PRODUCTELLINAE Schuchert and LeVene, emend. Sutton

Productids in which the visceral cavity is typically thin. The pedicle valve is convex and the brachial concave, with curvature following closely that of the pedicle. Cardinal process bifid in genera where it is known. Some genera were attached by cementation of part or nearly all of the pedicle valve to some outside object. Others were attached by hollow spines or possibly were only partly supported in an unattached position. Surface ornamentation variable, consisting of spines, costae, and rugae, different in different genera. Some productids have portions of the shell smooth.

Remarks.—This subfamily name was proposed by Schuchert and LeVene (1929, p. 17) without discussion or description. They assigned only one genus, *Productella*, to it. I am emending the subfamily to include all productids characterized by a thin visceral cavity, irrespective of their mode of living, and am transferring to it the Mississippian genera, *Strophalosia* King from the subfamily Strophalosiinae, and *Gigantella* Sarytscheva from the Productinae. The previously unassigned *Leptalosia* Dunbar and Condra and the new genus *Productina* belong here.

In 1913 Schuchert erected the subfamily Strophalosiinae to include productids which were "anchored to foreign objects by the spines or by most of the ventral shell." In this subfamily were placed *Chonopectus* Hall and Clarke, *Etheridgina* Oehlert, *Strophalosia* King, and *Aulosteges* Helmersen. Of these genera *Etheridgina* is not known from this country. *Chonopectus* is similar to typical Chonetidae in all external features, including the restriction of spines to a row along the cardinal area. It differs from typical *Chonetes s.s.* in the presence of a flattened, compressed, and slightly distorted pedicle beak due to attachment. Only one species of this genus is known and the known specimens are not well enough preserved to allow the internal features to be clearly distinguished. The inner surface of the valves apparently lacks the papillae which are characteristic of the Chonetidae. The writer feels that the chonetid characters of the shell are sufficient to warrant its inclusion in the Chonetidae.

The other genera assigned to the Strophalosiinae all possess characters of typical Productellinae. Cementation to some outside object is not considered of sufficient value to warrant the erection of a special subfamily to receive such forms. Furthermore, in some species of *Strophalosia* the shell attachment was apparently restricted to the youthful stage. Because attachment to a foreign object has been the basis for differentiation of the subfamily and because some of the forms assigned to it were not attached throughout life to any greater degree than were some other productids, including some genera of Productinae as *Juresania* of the Pennsylvanian and Permian for example, the validity of this subfamily seems questionable. The term Strophalosiinae is therefore discarded as a subfamily name and, except *Chonepectus*, the genera previously assigned to it are transferred to the subfamily Productellinae.

Genus LEPTALOSIA Dunbar and Condra, 1932
(See plate 62, figures 1,2)

Minute productids which are adnate on other shells or objects, being attached by a large part of the pedicle surface. The pedicle valve possesses a narrow cardinal area and an upturned margin equipped with simple spines, which adhere to the object of attachment. The brachial valve is smooth or lamellose and spineless. Internal features obscure.

Hinge teeth present in older species but probably lacking in post-Mississippian forms. Cardinal process small and bifid.

Leptalosia ranges from Middle Devonian through the Pennsylvanian. Throughout this time it exhibits increasing degeneracy. Devonian forms are larger and have fairly well developed teeth and sockets and cardinal process. Mississippian species possess feeble dentition and a distinct cardinal area with deltidium. In Pennsylvanian forms the teeth and sockets are practically obsolete. the cardinal area narrow and the deltidium scarcely distinguishable (Dunbar and Condra, 1932, p. 260).

Genotype, *Strophalosia scintilla* Beecher.

Remarks.—Greger (1920) assigned these forms to *Etheridgina*. Dunbar and Condra (1932, p. 261) have given an excellent summary of the facts, showing that the original description of *Etheridgina* emphasizes absence of a cardinal area and, because these American forms possess a cardinal area, they cannot be assigned to that genus. Greger observed the presence of a cardinal area on some British specimens which had been sent to him identified as *Etheridgina*, and accordingly he referred the American forms to that genus.

LEPTALOSIA SCINTILLA (Beecher)

Plate 62, figures 1, 2

Strophalosia scintilla BEECHER, *1890*, Am. Jour. Sci., (3), vol. 40, p. 243, pl. 9, figs. 10–13.—HALL AND CLARKE, *1892*, Paleontology New York, vol. 8, pt. 1, pl. 15B, figs. 32–34.—ROWLEY, *1908*, Missouri Bureau Geol. and Mines, vol. 8, 2nd ser., p. 76, pl. 17, figs. 26–29.—WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 144, pl. 18, figs. 29–23.

Etheridgina scintilla (Beecher), GREGER, 1920, Geol. Mag., vol. 57, no. 678, p. 536, pl. 14, figs. 12–14.

LEPTALOSIA KEOKUK (Beecher)

Strophalosia keokuk BEECHER, *1890*, Am. Jour. Sci. (3), vol. 40, p. 244, pl. 9, figs. 18–24.—HALL AND CLARKE, *1890*, Paleontology New York, vol. 8, pt. 1, pl. 17A, figs. 5–7.—WELLER, 1914, Illinois Geol. Survey, Mon. 1, p. 145, pl. 18, figs. 17–18.

Etheridgina keokuk (Beecher), GREGER, *1920*, Geol. Mag., vol. 57, no. 678, p. 536, pl. 14, figs. 9–11.

Genus STROPHALOSIA King, 1844

(See plate 64, figures 18, 19)

Shell productid in form, with distinct cicatrix on pedicle umbo for attachment to foreign object. Some species became free from cementation in mature stage. Pedicle valve with well defined area and prominent cardinal teeth but no dental laminae. Delthyrium closed by deltidium. Brachial cardinal area narrow. Cardinal process erect, bifid on anterior, and apparently trifid on posterior face, supported laterally by socket plates and continued anteriorly into a medium septum, which extends half the length of the valve. Surface of pedicle valve spinose, the spines near the beak often recurved and embracing some external object. In some forms all spines assisted in attachment. Brachial valve spinose, lamellose, or smooth and with distinct internal brachial ridges. Middle Devonian to Permian.

Genotype, *Orthis excavata* Geinitz.

STROPHALOSIA BEECHERI Rowley

Strophalosia beecheri ROWLEY, *1893*, Am. Geologist, vol. 12, p. 308, pl. 14, figs. 18–19; Missouri Bureau Geol. and Mines, vol. 8, 2nd. ser., p. 76, pl. 17, figs. 24–25—WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p 146., pl. 19, figs. 37–38.

STROPHALOSIA CYMBULA Hall and Clarke

Plate 64, figures 18, 19

Strophalosia cymbula HALL AND CLARKE, *1892*, Paleontology, New York, vol. 8 pt. 1, pl. 17A, figs. 2–4, 8–9.—HALL, *1897*, 14th. Rept. New York State Geologist, p. 355, pl. 7, fig. 5.—WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 145, pl. 19, figs. 35–36.

STROPHALOSIA FORTISPINOSA

Hinchey and Ray

Strophalosia fortispinosa HINCHEY AND RAY, *1935*, Jour. Paleontology, vol. 9, no. 3, p. 249, pl. 25, figs. 13–21.

STROPHALOSIA ORBICULATA

Hinchey and Ray

Strophalosia orbiculata HINCHEY AND RAY, *1935*, Jour. Paleontology, vol. 9, no. 3, p. 248, pl. 25, figs. 1–7.

STROPHALOSIA SUBCOSTATA Girty

Strophalosia subcostata GIRTY, *1910*, New York Acad. Sci., Ann. vol. 20, no. 3, pt. 2, p. 215.

STROPHALOSIA SUBELLIPTICA Hinchey and Ray

Strophalosia subelliptica HINCHEY AND RAY. *1935*, Jour. Paleontology, vol. 9, no. 3, p. 249, pl. 25, figs. 8–11.

Genus PRODUCTELLA Hall, 1867
(See plate 62, figures 3–6; text figure 1*a*)

Shell below medium size, deeply concavo-convex, with the curvature of the brachial valve following closely that of the pedicle valve, forming a thin visceral cavity. Hinge line straight, equal to or a little shorter than the greatest width. Narrow cardinal area on both valves, generally somewhat wider on the pedicle valve in Mississippian species. Delthyrium closed by deltidium. Cardinal teeth in pedicle valve, dental sockets and socket plates in the brachial. Surface of valve sparingly spinose, with the spines more or less irregularly arranged. Radiating markings more or less discontinuous, often elongate nodelike elevations rather than continuous costae. Concentric markings also rather indistinct. The indefiniteness of both radial and concentric markings is in contrast to most members of the Productidae. Internal features quite similar to those of other productids. The cardinal process is bilobed, with each of the two lobes appearing bilobed because of a small incision in the distal portion.

Genolectotype, *Productus subaculeatus* Murchison (Schuchert and Levene 1929, p. 100).

Remarks.—The genus *Productella* has been rather loosely conceived in the past and made to embrace a large number of species. Careful examination of the Mississippian forms referred to it indicates that most of them should probably be assigned elsewhere. In fact, as far as I can determine, *P. pyxidata* is the only species in Mississippian rocks which possesses both of the diagnostic characters of *Productella*, viz., the narrow cardinal areas and weakly developed articulating hinge teeth and sockets. *P. hirsutiformis* Walcott has the cardinal area, but in none of the descriptions is mention made of any articulating processes, and none have

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EXPLANATION OF PLATE 62

Figures natural size unless otherwise indicated. U.I. indicates University of Illinois collections; W.M. indicates Walker Museum, University of Chicago collections.

FIGS. *1, 2*—Genus *Leptalosia* Dunbar and Condra (p. 548)

1, 2, Leptalosia scintilla (Beecher), U.I. E-2325, Louisiana limestone, Clarksville, Mo. *1*, Two specimens attached to exterior of brachial valve of *Productella pyxidata* (Hall), ×1. *2*, Same, ×8, specimen at left showing exterior of a brachial valve and that at right the interior of a pedicle valve.

3–6—Genus *Productella* Hall (p. 550)

3–5, Productella pyxidata (Hall), Louisiana limestone, Clarksville, Mo. *3, 4*, Pedicle and brachial views of two specimens, U.I. E-1744. *5*, Interior of brachial valve, U.I. E-906.

6, Productella hirsutiformis (Walcott), "Mayes" formation (Chester), Fort Gibson, Okla. W.M. 16928.

7–15—Genus *Avonia* Thomas (p. 565)

7, 8, Avonia? indianensis (Hall), Salem limestone, Spergen Hill, Ind.; lateral and pedicle views, ×4, W.M. 14325.

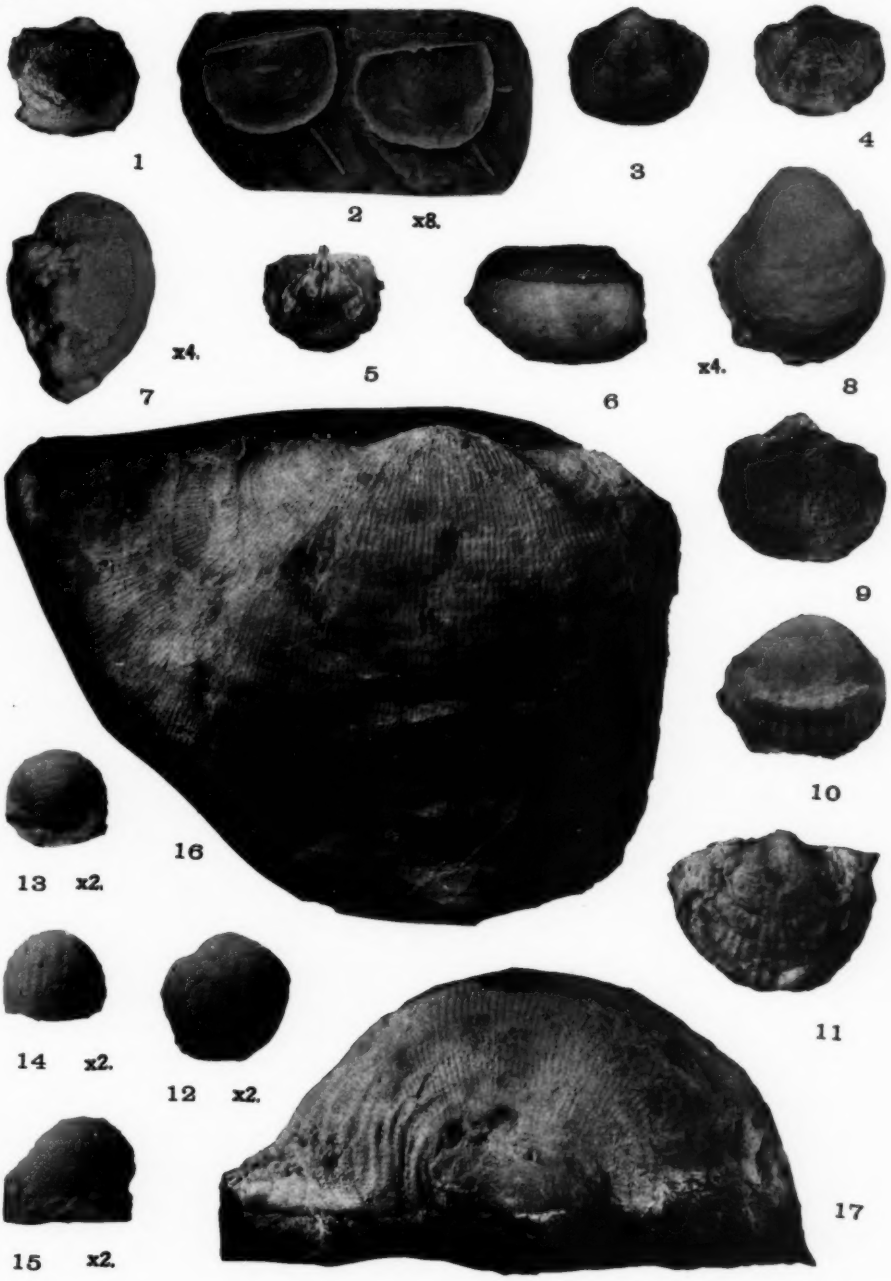
9–11, Avonia oklahomensis Snider, Moorefield shale, Spring Creek, Ark.; brachial and pedicle views, ×1, U.I. E-2328.

12–15, Avonia pustulifera (Moore), lower Burlington limestone, Osceola, Mo., syntypes, ×2, W.M. 32113. *12*, Pedicle view of a syntype. *13–15*, Posterior, pedicle, and lateral views of another syntype.

16, 17—Genus *Gigantella* Sarytcheval (p. 552)

16, Gigantella brazeriana (Girty), Big Snowy group, Montana; pedicle view of an incomplete valve, U.I. E-2327.

17, Gigantella gigantea (Sowerby), Upper Avon, England; posterior view of a typical specimen, W.M. 32638.



Sutton, Mississippian Brachiopoda (Productidae)

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been observed by me. In external appearance this species is much like *P. pyxidata*, and because of this and the presence of a cardinal area, it is retained in the genus. Essentially the same is true of *P. patula* Girty. Two species, *P. nummularis* and *P. sublaevis* from the Kinderhook, are retained although their affinities with *Productella* are doubtful. Both of these species are known only from the yellow sandstone at Kinderhook, Ill., the preservation being such as to render identification very difficult. They may well belong to some other genus, but on the basis of present knowledge I am unable to make any more definite assignment. *P. alifera* Girty likewise is doubtfully assigned to this genus. The only specimens examined by me are the types, the preservation of which is such as to obscure the cardinal area and articulating processes. The general shell markings and shape suggest affinity with *Productella*, and for want of a better designation it is retained in that genus.

PRODUCTELLA PYXIDATA (Hall)

Plate 62, figures 3,4; text figure 1*h*, *i*

Productus pyxidatus HALL, *1858*, Geol. Iowa, vol. 1, pt. 2, p. 498, pl. 3, figs. 8a–e.

Productus shumardianus HALL, *1858*, Geol. Iowa, vol. 1, pt. 2, p. 499, pl. 3, fig. 9 (not pl. 7, fig. 1).

Productella pyxidata (HALL), *1883*, Rept. New York State Geologist for 1882, pl. (17) 48, fig. 34.—HALL AND CLARKE, *1892*, Intro. Study Brachiopods, pt. 1, pl. 21, figs. 20, 23; Paleontology, New York, 1, vol. 8, pt. 1, pl. 17, fig. 34, pl. 17A, fig. 14.—KEYES, *1894*, Missouri Geol. Survey, vol. 5, p. 52, pl. 38, figs. 4a–d.—ROWLEY, *1908*, Missouri Bureau Geol. and Mines, vol. 8, 2nd ser., p. 77, pl. 17, figs. 5, 30–36.—WELLER, *1914*, Illinois Geol. Survey, Mon. 1, pp. 100–101, pl. 19, figs. 1–21.—GIRTY, *1915*, U. S. Geol. Survey, Bull. 598, p. 34.

PRODUCTELLA HIRSUTIFORMIS (Walcott)

Productus hirsutiforme WALCOTT, *1884*, U. S. Geol. Survey, Mon. 8, p. 133, pl. 2, fig. 10

Productella hirsutiformis (Walcott), GIRTY, *1909*, U. S. Geol. Survey, Bull. 377, p. 24, pl. 2, figs. 4–6; *1911*, U. S. Geol. Survey, Bull. 439, p. 50, pl. 3, figs. 1–4; *1915*, U. S. Geol. Survey, Bull. 593, p. 45, pl. 2, fig. 4; *1929*, U. S. Geol. Survey, Prof. Paper 154B, p. 83, pl. 9, fig. 10.—SNIDER, *1915*, Oklahoma Geol. Survey, Bull. 24, p. 78.

Productella hirsutiformis var. batesvillensis GIRTY, *1911*, U. S. Geol. Survey, Bull. 439, p. 51, pl. 3, fig. 5.—SNIDER, *1915*, Oklahoma Geol. Survey, Bull. 24, p. 78.

PRODUCTELLA NUMMULARIS (Winchell)

Strophalosia? nummularis WINCHELL, *1863*, Acad. Nat. Sci. Philadelphia, Proc., p. 4.

Productella nummularis (Winchell), WELLER, *1900*, St. Louis Acad. Sci., Trans., vol. 10, p. 71, pl. 1, figs. 9–10; *1914*, Illinois Geol. Survey, Mon. 1, p. 101, pl. 19, figs. 39–41.

PRODUCTELLA SUBLAEVIS Weller

Productella sublaevis WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 102, pl. 83, figs. 18–20.

PRODUCTELLA PATULA Girty

Productella patula GIRTY, *1915*, U. S. Geol. Survey, Bull. 598, p. 13, pl. 1, figs. 1–1b, 2.

PRODUCTELLA ALIFERA Girty

Productella alifera GIRTY, *1899*, U. S. Geol. Survey, Mon. 32, p. 530, pl. 58, figs. 10a–10c.

Genus PRODUCTINA Sutton, n. gen.

(See plate 63, figures 1–4)

Shell small, length and width subequal, somewhat longer than wide. Pedicle valve strongly convex, with the umbonal region protuberant beyond the hinge line. Brachial valve deeply concave, the curvature following that of the pedicle valve, forming a very thin visceral cavity with no differentiation into a visceral and produced portion. No fold or sinus. Surface of both valves marked by rounded costae. Concentric markings absent or inconspicuous. Bases of erect spines few and inconspicuous, usually confined to about two or three upon each side of the pedicle beak in an oblique row from the hinge line on each side of the beak to a point on the lateral margin in front of the cardinal extremity.

Genotype, *Productus sampsoni* Weller.

Remarks.—This genus may be the same as *Thomasia* Fredericks, which was based on *Productus margaritaceus* Phillips as the genotype. Schuchert and LeVene (1929, p. 123) showed that the name *Thomasia* is a homonym. Dunbar and Condra (1932, p. 188) mention *Thomasina* Fredericks but state that the name

is preoccupied. I have found no record of *Thomasina* proposed by Fredericks. Despite the finding of Schuchert and LeVene, Muir-Wood a year later (1930, p. 105) used the name *Thomasia* as in good standing. Specimens of *P. margaritaceus* have not been available for study.

PRODUCTINA SAMPSONI (Weller)
Plate 63, figures 1–4

Productus sampsoni WELLER, *1909*, Geol. Soc. America, Bull., vol. 20, p. 300, pl. 12, figs. 18–22; 1914, Illinois Geol. Survey, Mon. 1, p. 129, pl. 13, figs. 30–35.—GIRTY, *1915*, U. S. Geol. Survey, Bull. 598, p. 34. —MOORE, *1928*, Missouri Bureau Geol. and Mines, p. 265.

PRODUCTINA PARVULA (Winchell)

Producta parvula WINCHELL, *1863*, Acad. Nat. Sci. Philadelphia, Proc., p. 4.
Productus parvulus (Winchell), WELLER, *1901*, St. Louis Acad. Sci., Trans., vol. 11, p. 160, pl. 14, figs. 21–22; *1914*, Illinois Geol. Survey, Mon. 1, p. 128, pl. 14, figs. 24–25.

Genus GIGANTELLA Sarytcheval, 1928
(See plate 62, figures 16, 17)

Shell large and massive, with a long hinge line, which is about equal to the greatest width. The pedicle valve is especially thick and moderately convex. The brachial valve is concave, with curvature that follows closely the pedicle valve, forming a thin, uniform visceral chamber, which extends throughout the length of the shell. The surface is ornamented with flexuous costae, which are very fine and somewhat irregular. Without reticulate ornamentation on the umbones, although irregular wrinkles may occur on the auriculations and up the umbonal slopes.

Genotype, *Productus giganteus* (Martin).

Remarks.—This genus is much like *Kansuella* Chao except for the constant presence of a narrow cardinal area on both valves of the latter genus. An area is rarely developed on the pedicle valve of *Gigantella*. The costae are like those of *Linoproductus* Chao from which genus it may be distinguished by its long hinge line and thin visceral cavity.

Only one species of this genus, occurring in the Big Snowy group and Brazer formation of the northern Rocky Mountain region, is known from this country, and no other American forms seem to be closely allied to it. The species may represent an immigrant form. I hesitate to assign it to the Productellinae because of the great difference in size between it and other members, but the character of the visceral cavity seems to ally it more closely with these forms than with any of the Productinae.

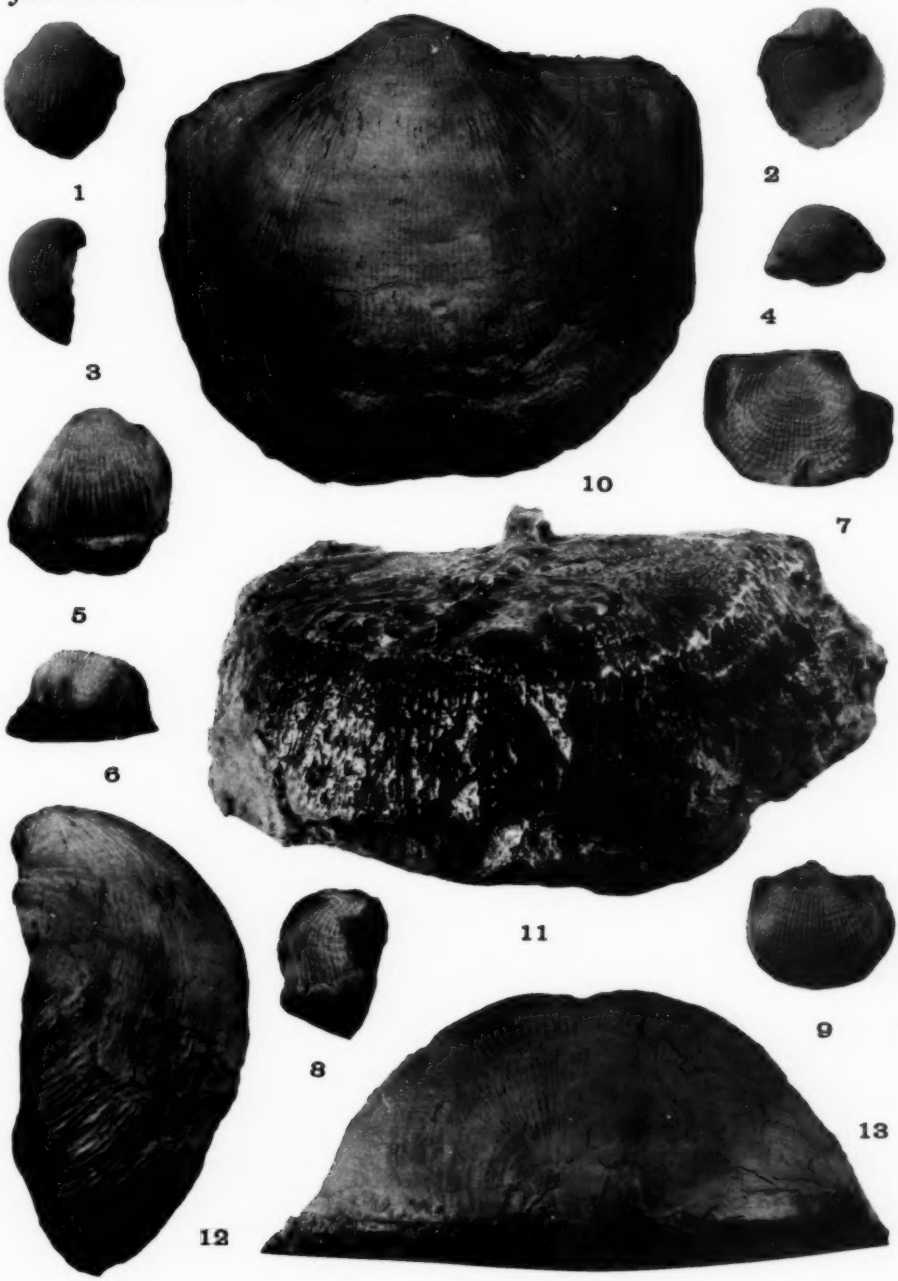
GIGANTELLA BRAZERIANA (Girty)
Plate 62, figure 16

Productus brazerianus GIRTY, *1920*, U. S. Geol. Survey, Prof. Paper 111 p. 643, pl. 53, figs. 1–2; *1927*, U. S. Geol. Survey, Prof. Paper 152, pl. 23, figs. 1–2.

EXPLANATION OF PLATE 63

Figures natural size unless otherwise indicated. U.I. indicates University of Illinois collections; W.M. indicates Walker Museum, University of Chicago collections.

FIGS. *1–4*—Genus *Productina* Sutton, n. gen. (p. 551)
1–4, *Productina sampsoni* (Weller), Chouteau limestone, Pettis County, Missouri; pedicle, brachial, lateral, and posterior views of holotype, ×2, W.M. 9695.
5–9—Genus *Marginicinctus* Sutton, n. gen. (p. 561)
5–8, *Marginicinctus marginicinctus* (Prout), St. Louis limestone, St. Louis, Mo. *5, 6* Pedicle and posterior views of a typical specimen, U.I. E-794. *7*, Mold of the exterior of another specimen, U.I. E-794. *8*, Lateral view of another specimen, U.I. E-2069.
9, *Marginicinctus wortheni* (Hall), Keokuk limestone, Hancock County, Illinois; pedicle view of the holotype, U.I. X-82.
10–13—Genus *Marginirugus* Sutton, n. gen. (p. 559)
10–13, *Marginirugus magnus* (Meek and Worthen). *10, 12, 13*, Pedicle, lateral, and posterior views of a specimen, Keokuk limestone, Monroe County, Illinois; W.M. 14765. *11*, Oblique view of interior of brachial valve showing rugose marginal ridge Keokuk limestone, Ste. Genevieve County, Missouri; holotype, U.I. X-81.



Sutton, Mississippian Brachiopoda (Productidae)

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Subfamily PRODUCTINAE Waagen, emend. Sutton

Productids in which the visceral cavity is typically moderate to deep, pedicle valve strongly convex and brachial valve flat or slightly concave; many forms are geniculated. The spines may be erect or oblique; if erect, they are usually confined to the pedicle valve, and if oblique, they are always on both valves. Some forms possess a small cicatrix of attachment on the pedicle valve. Some have a narrow cardinal area. Cardinal process trifid or a modification of the trifid type, where known, with the possible exception of some species now assigned to *Echinoconchus*. No articulating processes known. Surface ornamentation variable.

Within this subfamily there are representatives of five phylogenetic series While the majority of forms are sufficiently distinct to be readily distinguished, in a few cases it is difficult to separate them. In two instances, forms are so different in diagnostic features that it has been considered necessary to erect new genera to receive them, even though only one species is known for one of the genera. Future investigations may discover additional species for some genera which now contain very few.

The five phylogenetic series may be designated as (1) lirate-spinose, (2) costate-spinose, (3) spinose-costate, (4) spinose, and (5) semireticulate. It is possible that these should be considered as five generic types, and that the different forms, among those which embrace subdivisions, should be classed as subgenera. This would reduce the number of genera from eleven to five. I prefer to classify the different forms as genera, favoring a binomial rather than a trinomial designation. Only one genus is recognized in each of three of the five series. Three genera are assigned to the spinose series and five to the semireticulate series.

The lirate-spinose type is represented by *Linoproductus*, and the costate-spinose type by *Buxtonia*.

Possibly a second genus should be separated from *Avonia*, which comprises the spinose-costate type. Typical members of this genus are characterized by spines in youth and costae in later growth stages. Among American Mississippian species there are three which lack costae on the anterior portion of the shell. These are all small, and because of the possibility that they may be immature forms which might have developed costae if they had attained greater size, they have been retained in this genus rather than assigned to a new one.

The essentially spinose forms are placed in three genera. Species of two of these are ornamented with spines arranged in concentric bands. On *Pustula* the spines are of one size or rank on each band and occur in one row on each band. *Echinoconchus* has the spines arranged in several rows on each band, one row of large spines and other rows of smaller ones. The third genus, *Krotovia*, is ornamented by spines that are closely and irregularly distributed over the shell.

The largest number of genera is found among the semireticulate forms. In this group the differentiation into genera is based primarily on the character of the brachial valve, except in the genus *Marginicinctus*, where the diagnostic feature, the marginal ring around the anterior part of the shell, is more obvious on the pedicle valve. *Dictyoclostus*, as here classified, contains rather coarsely costate forms with a brachial valve that is regularly curved throughout its extent. Most semireticulate species have a geniculated brachial valve, although some have it less abruptly bent. *Productus* possesses a shelly plate or diaphragm around the margin of the visceral disc of the brachial valve and has the reticulations least developed of any member of the series. *Marginifera* possesses an internal ridge, which is elevated above the level of the disc around the margin of the brachial valve. *Marginirugus* is characterized internally by a prominent rugose thickening of the anterior and lateral margins of the disc of the brachial valve. This thick-

ened portion of the valve does not rise above the level of the visceral disc but extends the surface of the disc toward the pedicle valve. The brachial valve appears to be geniculate when viewed from the inside, but from the outside it appears to be less sharply and more uniformly deflected. The essential characters of the five genera of this series are shown in Fig. 1*b–g*.

Genus PUSTULA Thomas, 1914
(See plate 66, figures 8–10)

Shell productid in outline, pedicle valve convex and the brachial flat or gently concave, forming a moderately deep visceral cavity. Shell geniculate or nongeniculate. Surface of both valves ornamented with oblique spines, which are arranged on concentric bands, each somewhat higher at the anterior margin than the posterior part of the next succeeding one. The bands increase in width from the beak to the anterior margin. In some of the species assigned to this genus the bands are more or less indefinite. On each band the spines are of the same rank or size and occur in one row.

Genotype, *Productus pustulosus* Phillips.

Remarks.—The occurrence of the spines in a single row on each band distinguishes *Pustula* from *Echinoconchus* Weller, on which each band bears spines of two sizes in more than one row to the band. Bands on *Echinoconchus* are usually more definite than on *Pustula*. *Pustula* agrees with *Overtonia* Thomas in surface ornamentation but differs from it in having brachial impressions, which rise near the center of the brachial valve and diverge at 180° whereas in *Overtonia* they rise near the

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EXPLANATION OF PLATE 64

Figures natural size unless otherwise indicated. U.I. indicates University of Illinois collections; W.M. indicates Walker Museum, University of Chicago collections.

FIGS. *1–8*—Genus *Dictyoclostus* Muir-Wood (p. 562)

1–4, *Dictyoclostus mesialis* (Hall). *1–3*, Pedicle, brachial and posterior views of specimens from Keokuk limestone, Warsaw Ill., U.I. E-521. *4*, Mold of exterior of brachial valve of another specimen, Keokuk limestone, Nauvoo, Ill., U.I. E-512.

5–8, *Dictyoclostus crawfordsvillensis* (Weller), Keokuk limestone, Crawfordsville, Ind., W.M. 14381. *5–7*, Posterior, lateral, and pedicle views of a typical specimen. *8*, Brachial view of another specimen.

9–13—Genus *Productus* Sowerby (p. 558)

9–12, *Productus elegans* Norwood and Pratten. *9*, Pedicle view of a specimen from the Chester series, Chester, Ill., U.I. E-7491. *10*, *11*, Brachial and lateral views of another specimen, the diaphragm being shown in the former; same horizon and locality, U.I. E-769. *12*, Pedicle view, showing plane of dehiscence along which the shell usually breaks; Chester series, Grayson County, Kentucky; W.M. 1430.

13, *Productus productus* (Martin), Lower Carboniferous, England; pedicle view of a specimen, U.I. E-610.

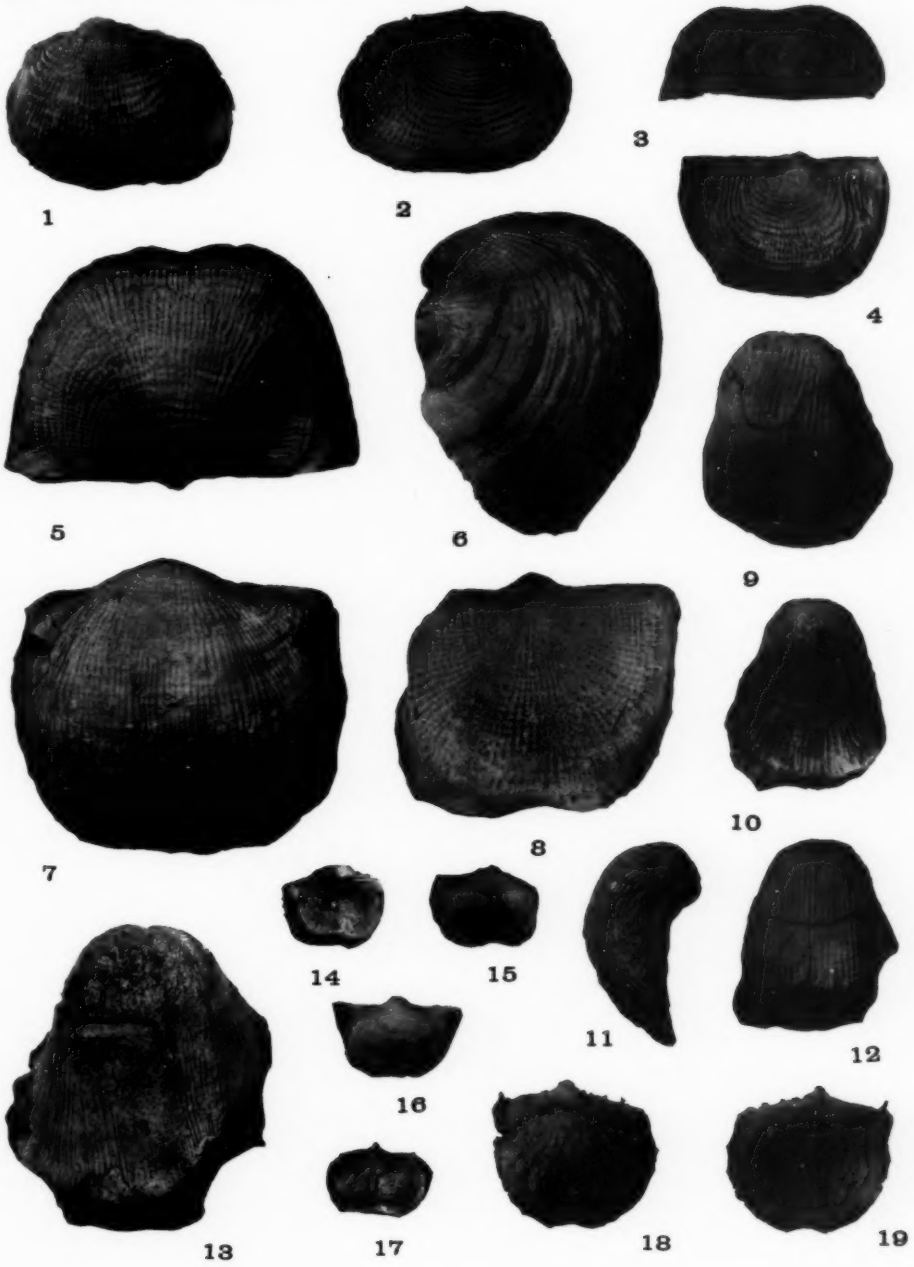
14–17—Genus *Marginifera* Waagen (p. 561)

14, *15*, *17*, *Marginifera splendens* (Norwood and Pratten), Pennsylvanian, Herrin quadrangle, Illinois. *14*, *15*, Brachial and pedicle views of a specimen, U.I. F-1631. *17*, Interior of brachial valve, showing marginal ridge around the visceral disc, U.I. F-1631.

16, "*Marginifera wabashensis* (Norwood and Pratten)", Pennsylvanian, Canton quadrangle, Illinois, U.I. F-1919. Pedicle view of a specimen. This species has a thin visceral cavity, curvature of the brachial valve closely following that of the pedicle valve, and the brachial valve lacks a thickened band or ridge. According to the classification here proposed, it does not belong in the same genus with *M. splendens*.

18, *19*—Genus *Strophalosia* King (p. 549)

18, *19*, *Strophalosia cymbula* Hall and Clarke, New Providence shale, south of Louisville, Ky.; pedicle and brachial views of the holotype, W.M. 11897.



Sutton, Mississippian Brachiopoda (Productidae)

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beak and diverge gradually forward. No specimens of *Overtonia* are known from American Mississippian rocks.

One species, *P. arctifossa* Moore, is somewhat doubtfully assigned to this genus, for the general shape is not typically productid. Only the type specimens have been available for study and they do not show internal characters. *Pustula pusilla* (Girty), originally described as *Productus moorefieldanus* var. *pusillus*, has been elevated to specific rank and assigned to *Pustula*, although *Productus moorefieldanus* Girty has been included in *Avonia*. The only resemblance between the two that I have been able to see is general shape. Three other species that are ornamented only with spines, which have formerly been included in *Pustula*, *P. incrassata*, *P. indianensis*, and *P. laevicula* have been assigned to *Avonia*, reasons for this assignment being given in the discussion of *Avonia*. The form classified as *Echinoconchus subsulcatus* var. *janus* (Girty) may be a *Pustula*. Reasons for placing it in *Echinoconchus* are given in the discussion of that genus.

PUSTULA ARCTIFOSSA Moore

Pustula arctifossa MOORE, *1928*, Missouri Bureau Geol. and Mines, p. 269, pl. 10, figs. 7–11.

PUSTULA MORBILLIANA (Winchell)

Productus morbillianus WINCHELL, *1865*, Acad. Nat. Sci. Philadelphia, Proc., p. 113.

Echinoconchus morbillianus (Winchell), WELLER, *1914*, Illinois, Geol. Survey, Mon. 1, p. 142, pl. 18, figs. 13–15.

Buxtonia? morbilliana (Winchell), GIRTY, *1915*, Mo. Bureau Geol. and Mines, vol. 13, 2nd ser., p. 349.

PUSTULA PUSILLA Girty

Productus moorefieldanus var. *pusillus* GIRTY, *1911*, U. S. Geol. Survey, Bull. 439, p. 49, pl. 3, figs. 7–9.

Pustula moorefieldana var. *pusilla* (Girty), GIRTY, *1915*, Missouri Bureau Geol. and Mines, vol. 13, 2nd ser., p. 348.

PUSTULA INCONSPICUA Girty

Pustula inconspicua GIRTY, *1926*, U. S. Geol. Survey, Prof. Paper 146, p. 28, pl. 5, figs. 17–21b.

Genus ECHINOCONCHUS Weller, 1914
(See plate 66, figures 1–6)

Like *Pustula*, except that the spines on each band are of two ranks or sizes. In most forms the larger spines are posterior in position on each band, but in some they are anterior, and in some species the fine spines are between the larger as well as in front of them. All spines lie close to the shell. The valves are non-geniculate.

Genotype, *Anomites punctatus* Martin.

Remarks.—Weller proposed this generic name (1914, p. 139) for the group of productids typified by *P. punctatus*, but he included in his definition all species that possessed spines arranged on bands. In the same year, Thomas (1914, p. 261) proposed the name *Pustula* for pustulose productids typified by *Productus pustulosus*. Like Weller, he included all forms ornamented by spinose bands, irrespective of the number of rows and size of spines. Since Weller's publication was in November and Thomas' in June it was considered for several years that the two names were synonymous and that *Pustula* had priority. Chao (1928, p. 53) was the first to call attention to the fact that the genotype of *Echinoconchus* is characterized by bands carrying spines of different sizes, except in the very early stage, whereas the genotype of *Pustula* possesses only one rank of spines to each band. He proposed to retain *Echinoconchus* with subgeneric rank. It has since been restored to generic status by Muir-Wood (1930, p. 106) inasmuch as there seems to be a real justification for regarding it as a genus.

All of the species included in this genus, except *E. subsulcatus* (Girty) and *E. subsulcatus* var. *janus* (Girty), are referred to it without question. The types of the two forms mentioned are internal molds that retain none of the characteristic surface features. The concentric bands are evident, but the character of the spines is not clear. One small area of shell material is preserved on one of the types of *E. subsulcatus*, and there seems to be trace of spines of two sizes. The type of

the variety *janus* possesses no shell and markings of only large spines have been preserved. It is possible that this form is not an *Echinoconchus* but a *Pustula*. The general shape of the two is similar, but the concentric bands are not so definite on *janus*. The large spines on the variety were obviously larger than the large ones on *E. subsulcatus*. Because of uncertainty as to the character of the spines, these forms are tentatively referred to *Echinoconchus*.

ECHINOCONCHUS ALTERNATUS (Norwood and Pratten)
Plate 66, figures 1–4

Productus alternatus NORWOOD AND PRATTEN, *1855*, Acad. Nat. Sci. Philadelphia, Jour. (2), vol. 3, p. 20, pl. 2, figs. 1a–e. HALL, *1883*, Rept. New York State Geologist for 1882, pl. 49, (18) fig. 14.—HALL AND CLARKE, *1892*, Paleontology New York, vol. 8, pt. 1, pl. 18, fig. 14.

Productus vittatus HALL, *1858*, Geol. Iowa, vol. 1, pt. 2, p. 639; *1883*, Rept. New York State Geologist for 1882, pl. 49, (18) figs. 15–17.—HALL AND CLARKE, *1892*, Paleontology New York, vol. 8, pt. 1, pl. 18, figs. 15–17.—KEYES, *1894*, Missouri Geol. Survey, vol. 5, p. 43.

Productus gradatus SWALLOW, *1863*, St. Louis Acad. Sci., Trans., vol. 2, p. 93.

Echinoconchus alternatus (Norwood and Pratten), WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 138, pl. 17, figs. 1–7.

Pustula alternata (Norwood and Pratten), SNIDER, *1915*, Oklahoma Geol. Survey, Bull. 24, pt. 2, p. 82.—GIRTY, *1915*, Missouri Bureau Geol. and Mines, vol. 13, 2nd ser., p. 348.—BUTTS, *1926*, Alabama Geol. Survey, Special Rept. 14, pl. 57, figs. 17–19.

Pustula aff. *P. gradata*, GIRTY, *1929*, U. S. Geol. Survey, Prof. Paper 154 B, p. 86.

ECHINOCONCHUS GENEVIEVENSIS Weller

Echinoconchus genevievensis WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 140, pl. 18, figs. 1–6.

Pustula genevievensis (Weller), BRANSON AND GREGER, *1918*, Geol. Soc. America, Bull., vol. 29, p. 315, pl. 19, figs. 1–2.

ECHINOCONCHUS BISERIATUS (Hall)
Plate 66, figures 5–7

Productus fimbriatus NORWOOD AND PRATTEN, *1855*, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 3, p. 19 (not *P. fimbriatus* Sowerby).

Productus biseriatus HALL, *1856*, Albany Inst., Trans., vol. 4, p. 12.—WHITFIELD, *1882*, Am. Mus. Nat. Hist., Bull., vol. 1, pl. 6, figs. 8–12.—HALL, *1883*, Indiana Geol. Survey, 12th. Rept. p. 325, pl. 29. figs. 8–12.—KEYES, *1894*, Missouri Geol. Survey, vol. 5, p. 43.—BEEDE, *1906*, Indiana Geol. Survey, 30th Ann. Rept., p. 1299, pl. 19, fig. 6; pl. 22, figs. 8–12.—GIRTY, *1911*, U. S. Geol. Survey, Bull. 439, p. 46, pl. 3, figs. 10–11.

Echinoconchus biseriatus (Hall), WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 141, pl. 17, figs. 10–15.—STOYANOW, *1926*, Am. Jour. Sci., vol. 12, p. 317.—HERNON, *1935*, Jour. Paleontology, vol. 9, no. 8, p. 679.

EXPLANATION OF PLATE 65

Figures natural size unless otherwise indicated. U.I. indicates University of Illinois collections; W.M. indicates Walker Museum, University of Chicago collections.

FIGS. *1–7*—Genus *Buxtonia* Thomas (p. 564)

1, *Buxtonia semicircularis* (Sutton and Wagner), Kinkaid limestone, Caldwell County, Kentucky; pedicle view, W.M. 30916.

2–4, *Buxtonia* sp., Keokuk formation, Floyd County, Indiana; posterior, pedicle, and brachial views of a specimen, U.I. E-683.

5, *Buxtonia incurvata* (Sutton and Wagner), Clore limestone, Illinois and western Kentucky; lateral view of a specimen, W.M. 34452.

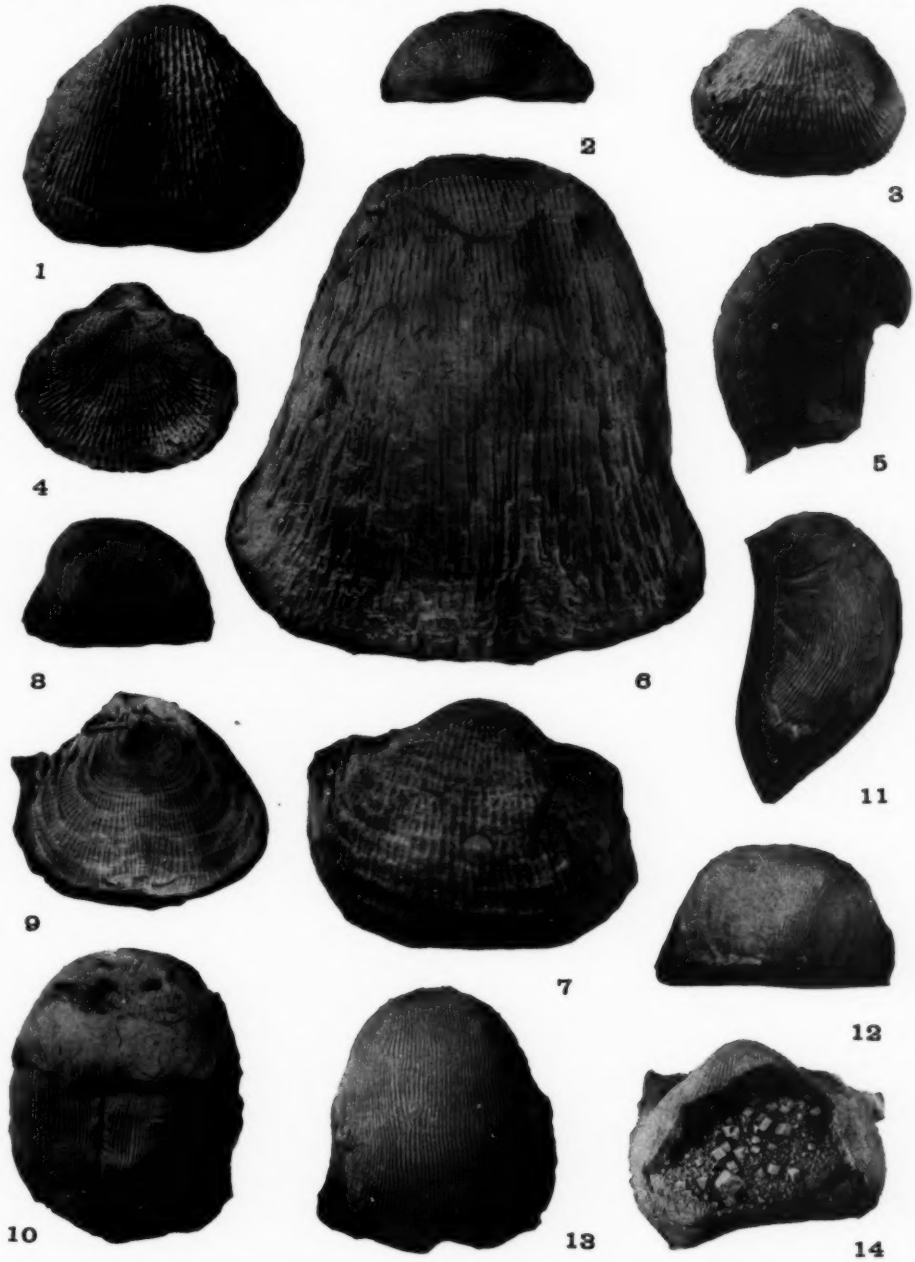
6, *Buxtonia viminalis* (White), Keokuk limestone, (locality??); pedicle view, U.I. E-2022.

7, *Buxtonia scabricula* (Martin), Upper Avon, Derbyshire, England; pedicle view, W.M. 32664.

8–14—Genus *Linoproductus* Chao (p. 557)

8–13, *Linoproductus ovatus* (Hall). *8–10*, Posterior view, mold of brachial valve, and pedicle view, of specimens from the St. Louis limestone, Glasgow, Ky., U.I. E-780; note broken pedicle valve exposing mold of trail of brachial valve. *11–13*, Lateral, posterior, and pedicle views of another specimen, St. Louis limestone, (locality??), U.I. E-2326.

14, *Linoproductus cora* (D'Orbigny), Pennsylvanian, Grand Tower, Ill., pedicle view, break in valve showing depth of visceral cavity; U.I. F-3986.



Sutton, Mississippian Brachiopoda (Productidae)

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Pustula biseriata (Hall), SNIDER, *1915*, Oklahoma Geol. Survey, Bull. 24, pt. 2, p. 83.—GIRTY, *1915*, Missouri Bureau Geol. and Mines, vol. 13, 2nd ser., p. 348—BUTTS, *1926*, Alabama Geol. Survey, Special Rept. 14, pl. 57, fig. 14.

ECHINOCONCHUS RODEOENSIS Hernon

Echinoconchus rodeoensis HERNON, *1935*, Jour. Paleontology vol. 9, no. 8, p. 679, pl. 81, fig. 3.

ECHINOCONCHUS SUBSULCATUS (Girty)

Productus subsulcatus GIRTY, *1911*, U. S. Geol. Survey, Bull. 439, p. 47, pl. 3, figs. 12–14.

Pustula subsulcata (Girty), SNIDER, *1915*, Oklahoma Geol. Survey, Bull. 24 pt. 2. p. 83.—GIRTY, *1915*, Missouri Bureau Geol. and Mines, 2nd ser., vol. 13, p. 348.

ECHINOCONCHUS SUBSULCATUS var. JANUS (Girty)

Productus subsulcatus var. *janus* GIRTY, *1911*, U. S. Geol. Survey, Bull. 439, p. 48, pl. 3, fig. 15.

Pustula subsulcata var. *janus* (Girty), GIRTY, *1915*, Mo. Bureau Geol. and Mines, vol.13, 2nd ser. p. 348.

Genus KROTOVIA Fredericks, 1928
(See plate 66, figures 12, 13)

Pustulose forms with the surface marked by a tuberculose ornamentation consisting of many fine, subequal, and irregularly spaced spinules, which are of the nature of spine bases produced anteriorly. There are neither definite rugae nor concentric bands, although irregular concentric growth lines may occur. The visceral cavity is moderately deep and uniform. No marked sinus. Tubercules occasionally transformed into indefinite and incipient costae near the anterior margin. No pronounced geniculation.

Genotype, *Productus spinulosus* Sowerby.

Remarks.—This genus most closely resembles *Waagenoconcha* Chao but lacks the quincunxial arrangement of spines and the rather pronounced sinus that characterize the latter. Only one species of this genus is known from this country.

KROTOVIA ECHINATA (Moore)
Plate 66, figures 12, 13

Pustula echinata MOORE, *1928*, Missouri Bureau Geol. and Mines, 2nd ser., vol. 21, p. 268, pl. 11, figs. 22–27.

Genus LINOPRODUCTUS Chao, 1927
(See plate 65, figures 8–14)

Productids with the pedicle valve strongly convex and the brachial valve flat or slightly concave in the visceral area and more or less strongly geniculate anteriorly, forming a large visceral cavity and a trail. The geniculation is usually less pronounced in Mississippian than in later species. In many Mississippian specimens the brachial valve is strongly and evenly curved but not geniculate in the strict sense. Surface covered by fine radiating, often flexuous costae or lirae. Concentric rugae occur on the ears and up the posterolateral slopes but are usually not well developed on the umbo, so that definite reticulate ornamentation is lacking. Erect spines are scattered over the pedicle valve and one or two rows of spines occur along the cardinal margin. Brachial valve spineless. Shell substance usually thin. The pedicle valve is narrow as compared with the semireticulate type of productids.

Dunbar and Condra (1932, p. 240) have given a good diagnosis of the internal features of this genus. The cardinal process is short with a flaring base, which grades into rather stout lateral ridges below the hinge line. The brachial adductor scars are large and bear a sculpture of radiating low rounded ridges. The pedicle scars consist of an elongate oval adductor area in front of the beak, and a pair of larger diductor scars that are located at the side and partly in front of the adductors. The adductors bear sculpture like the brachial adductors. The scars are separated, striated and flabellate.

Genotype, *Productus cora* D'Orbigny.

Remarks.—About as much difficulty has been encountered in assigning species to this genus as in the case of any other. Gradations between the lirae or very fine

costae, which characterize *L. ovatus*, and coarser costae, which occur on members of the semireticulate group, are common. Members of this genus possess a hinge line that is characteristically shorter, relatively, than that of the semireticulate forms. The rugae are normally less distinct on *Linoproductus* than *Dictyoclostus*. Forms with costae of intermediate size, if they have a long hinge line and well developed rugae have been assigned to *Dictyoclostus* and the ones with a relatively short hinge line, to *Linoproductus*. Three species, previously called *Productus altonensis*, *P. scitulus*, and *P. parviformis*, fall in this category. The radial markings are coarser than on *L. ovatus* and finer than on semireticulate genera. *P. altonensis* has been placed in *Linoproductus*, the other two in *Dictyoclostus*. This assignment is perhaps largely a matter of personal opinion.

Linoproductus ovatus (Hall)
Plate 65, figures 8–13

Productus ovatus Hall, *1858*, Geol. Iowa, vol. 1, pt. 2, p. 674, pl. 24, fig. 1; *1883*, Rept. New York State Geologist for 1882, pl. 49, (18) fig. 19.—Hall and Clarke, *1892*, Paleontology New York, vol. 8, pt. 1, pl. 18, fig. 19.—Keyes, *1894*, Missouri Geol. Survey, vol. 5, p. 44.—Weller, *1914*, Illinois Geol. Survey, Mon. 1, p. 132, pl. 16, figs. 1–15.—Snider, *1915*, Oklahoma Geol. Survey, Bull. 24, pt. 2, p. 83.—Weller, J. M., *1931*, Kentucky Geol. Survey, Symposium, p. 288, pl. 43, figs. 8a, b.

Productus pileiformis McChesney, *1859*, Descr. New Paleozoic Fossils, p. 40.—Whitfield, *1891*, New York Acad. Sci., Annals, vol. 5, p. 582, pl. 13, figs. 13–14; *1895*, Ohio Geol. Survey, vol. 7, p. 470, pl. 9, figs. 13–14.—Girty, *1909*, U. S. Geol. Survey, Bull. 377, p. 26, pl. 2, fig. 7; 1911, U. S. Geol. Survey, Bull. 439, p. 44, pl. 4, figs. 1–2; *1915*, U. S. Geol. Survey Bull. 593, p. 48—Morse, *1911*, Ohio State Acad. Sci., Proc., vol. 5, p. 370, figs. 8a–c.

Productus laevicostus White, *1860*, Boston Soc. Nat. Hist., Jour., vol. 7, p. 230.—Hall and Whitfield, *1877*, U. S. Geol. Expl. 40th Par., vol. 4, p. 266, pl. 5, figs. 7–8.—Keyes, *1894*, Missouri Geol. Survey, vol. 5, p. 41, pl. 38, fig. 1.—Weller, St. Louis Acad. Sci. Trans., vol. 10, p. 71, pl. 1, figs. 1–2.—Girty, *1903*, U. S. Geol. Survey, Prof. Paper, 16, p. 284; 1915, U. S. Geol. Survey, Bull. 598, p. 34.

Productus coraeformis Swallow, *1863*, St. Louis Acad. Sci., Trans., vol. 2, p. 94.

Productus prattenianus White, *1874*, Prelim. Rept. Invert. Fossils, p. 17; U. S. Geol. Survey W. 100th Mer., vol. 4, p. 113.

Productus laevicosta White, Girty, *1899*, U. S. Geol. Survey, Mon. 32, p. 534, pl. 69, figs. 9a–c.—Stoyanow, *1926*, Am. Jour. Sci., vol. 12, p. 317.

Productus ovatus var. *minor* Snider, *1915*, Oklahoma Geol. Survey, Bull. 24, pt. 2, p. 79.

Productus ovatus var. *latior* Snider, *1915*, Oklahoma Geol. Survey, Bull. 24, pt. 2, p. 79.

Linoproductus ovatus (Hall), Hernon, *1935*, Jour. Paleontology, vol. 9, no. 8, p. 682.

Linoproductus tenuicostus (Hall)

Productus tenuicostus Hall, *1858*, Geol. Iowa, vol. 1, pt. 2, p. 675, pl. 24, figs. 2a–d; *1883*, Rept. New York State Geologist for 1882, pl. 49 (18), fig. 18.—Hall and Clarke, *1892*, Paleontology New York, vol. 8, pt. 1, pl. 18, fig. 18.—Keyes, *1894*, Missouri Geol. Survey, vol. 5, p. 44.—Weller, *1914*, Illinois Geol. Survey, Mon. 1, p. 119, pl. 10, figs. 25–27, pl. 11, figs. 1–5.

Linoproductus altonensis
(Norwood and Pratten)

Productus altonensis Norwood and Pratten, *1855*, Philadelphia Acad. Sci., Jour., (2), vol. 3, p. 7, pl. 1, figs. 1a–c.—Keyes, *1894*, Missouri Geol. Survey, vol. 5, p. 43.—Weller, *1914*, Illinois Geol. Survey, Mon. 1, p. 124, pl. 10, figs. 14–24.—Hernon, *1935*, Jour. Paleontology, vol. 9, No. 8, p. 681.

Productus gallatinensis Girty, *1899*, U. S. Geol. Survey, Mon. 32, pt. 2, p. 533, pl. 8, figs. 7–11; *1929*, U. S. Geol. Survey, Prof. Paper 154 B, p. 85.—Beede, *1906*, Indiana Geol. Survey, 30th Ann. Rept., p. 1302, pl. 17A, figs. 2–2a.

Productus burlingtonensis Hall, Beede, *1906*, Indiana Geol. Survey, 30th Ann. Rept., p. 1301, pl. 17A, figs. 1–1c.

Linoproductus croneisi Branson

Linoproductus croneisi Branson, *1937*, Jour. Paleontology, vol. 11, no. 8, p. 656, pl. 89, figs. 13–15.

Genus Productus Sowerby, 1814
(See plate 64, figures 9–13; text figure 1*d*)

Shell elongate, geniculate, with long trail. Hinge short. Shell costate in all growth stages, costae numerous and often flexuous. Many specimens display

a fasciculate arrangement of the costae, especially around the anterior margin of the pedicle valve. Wrinkles or rugae few and seldom prominent. Spines in rows on the ears and cardinal slopes and scattered over the pedicle valve. Pedicle valve convex, brachial valve flat or slightly concave. No delthyrium, cardinal area, or articulating processes. The diagnostic feature of the genus is a thin shelly plate or diaphragm, which is an outgrowth from the brachial valve at its point of geniculation. The diaphragm is developed around the lateral and anterior margins of the visceral disc and extends from it across the space between the valves. It forms a plane of dehiscence along which the shell usually breaks.

Genotype, *Anomites productus* Martin.

Remarks.—P. phillipsi is assigned to this genus with some question. In none of the descriptions is any mention made of a diaphragm and no specimens have been available for study. The original figure of the brachial valve suggests a diaphragm and therefore it is placed in *Productus* pending more information.

PRODUCTUS ELEGANS Norwood and Pratten
Plate 64, figures 9–12

Productus elegans NORWOOD AND PRATTEN, *1855*, Acad. Nat. Sci. Philadelphia, Jour., (2), vol. 3, p. 3, pl. 1, figs. 7a–c.—HALL AND WHITFIELD, *1877*, U. S. Geol. Expl. 40th Par., vol. 4, p. 268, pl. 5, figs. 3, 4.—WHITFIELD, *1891*, New York Acad. Sci., Annals, vol. 5, p. 581, pl. 13, figs. 15, 16; *1895*, Ohio Geol. Survey, vol. 7, p. 669, pl. 9, figs. 15, 16.—HERNON, *1935*, Jour. Paleontology, vol. 9, no. 8, p. 680, pl. 81, figs. 2a, b.

Productus flexistria NORWOOD AND PRATTEN, *1855*, Acad. Nat. Sci. Philadelphia, Jour., 2nd ser., vol. 3, p. 6.

Productus cestriensis WORTHEN, *1860*, St. Louis Acad. Sci., Trans., vol. 1, p. 570.—KEYES, *1894*, Missouri Geol. Survey, vol. 5, p. 44.—WELLER, *1897*, New York Acad. Sci., Trans., vol. 16, p. 256, pl. 18, figs. 7–9.—MORSE, *1911*, Ohio State Acad. Sci., Proc., vol. 5, p. 372, figs. 9a–g.

Diaphragmus elegans (Norwood and Pratten), GIRTY, *1910*, New York Acad. Sci., Annals, vol. 20, p. 217.—WELLER, *1914*, Illinois State Geol. Survey, Mon. 1, p. 136, pl. 12, figs. 8–17.—SNIDER, *1915*, Oklahoma Geol. Survey, Bull. 24, pt. 2, p. 84.—GIRTY, *1915*, U. S. Geol. Survey, Bull. 593, p. 59, pl. 3, figs. 5, 5a.—STOYANOW, *1926*, Am. Jour. Sci., vol. 12, p. 317.—BUTTS, *1926*, Alabama Geol. Survey, Spec. Rept. 14, pl. 65, figs. 6–9.—GIRTY, *1927*, U. S. Geol. Survey, Prof. Paper, 152, pl. 23, figs. 20–27.—WELLER, J. M., *1931*, Kentucky Geol. Survey, Symposium, p. 280, pl. 39, figs. 9a, b.

PRODUCTUS FASICULATUS McChesney

Productus fasiculatus MCCHESNEY, *1860*, Descr. New Paleozoic Fossils, p. 38.—BASSLER, *1909*, Virginia Geol. Survey, Bull. 11A, pl. 29, figs. 12, 13.—HERNON, *1935*, Jour. Paleontology, vol. 9, no. 8, p. 681.

Diaphragmus elegans (Norwood and Pratten), GIRTY, *1911*, U. S. Geol. Survey, Bull. 439, p. 51, pl. 4, figs. 4, 5.

Diaphragmus fasiculatus (McChesney), GIRTY, *1915*, U. S. Geol. Survey, Bull. 593, p. 56, pl. 3, figs. 1–4.

PRODUCTUS PHILLIPSI Norwood and Pratten

Productus phillipsi NORWOOD AND PRATTEN, *1855*, Acad. Nat. Sci. Philadelphia, Jour., 2nd ser., vol. 3, p. 8, pl. 1, figs. 2a–c.

Diaphragmus phillipsi (Norwood and Pratten), BRANSON AND GREGER, *1918*, Geol. Soc. America, Bull., vol. 29, p. 314, pl. 19, figs. 5–6.

Genus MARGINIRUGUS Sutton, n. gen.
(See plate 63, figures 10–13; text figure 1*g*)

Shell large, subhemispherical, broader than long, with the greatest width at or near the hinge line. Pedicle valve highly arched, with the curvature more abrupt posteriorly, and only slightly protuberant beyond the hinge line. Brachial valve flattened posteriorly and only slightly concave over the visceral disc; not geniculate, but rather abruptly and strongly curved beyond the visceral disc. Surface of both valves marked with somewhat obscure, low, rounded, radiating costae which are relatively slender for the size of the shell. More or less indistinct rugae occur over the posterior portions of both valves. Pedicle valve with a more or less indistinct shallow, narrow, mesial sinus and the brachial valve with a low narrow fold in the anterior half. Pedicle valve with rather obscure spine bases scattered sparsely over

the shell near the anterior and lateral margins and groups of more conspicuous ones near the cardinal margins. The cardinal spines are larger toward the cardinal extremities and are sometimes arranged in three or four oblique rows, with two to four spines in each row. Brachial valve spineless.

Pedicle muscle scars rather strongly developed, and the entire inner surface roughened by fine pits, the smoothest portion of the valve being the part that was in contact with the opposite valve. The brachial valve of the holotype of *M. magnus* possesses a large, strong, cardinal process, which is apparently bifid at its extremity. This apparent bifid character does not seem to be normal, however. One branch is almost in line with the median septum and the other developed on the right side. Several other specimens of the species that have been examined also have the right portion of the process better developed than the left, but the trifid character of the process is evident on these. No explanation is offered for this seemingly anomalous condition. A pronounced median septum extends anteriorly from the base of the process for three-fourths or more of the length of the visceral disc. A cardinal ridge extends laterally from each side of the base of the cardinal process nearly parallel to the cardinal margin. The brachial muscle impressions are anterior to the middle of the valve.

The brachial valve is not sharply geniculate, but it curves strongly toward the lateral and anterior margins. Parallel to these margins a prominent rugose ridge or thickening occurs around the valve where it is in contact with the pedicle valve. This ridge differentiates the visceral portion from the part in contact with the pedicle valve. This is in sharp contrast to most productids, in which the brachial valves are geniculate or very sharply curved. In most of those forms the brachial valve below the bend is marked only by costae. The ridge is unlike that of *Marginifera* which is elevated above the surface of the brachial visceral disc adjacent to the ridge, for in *Marginirugus* the ridge does not rise above the general level of the brachial disc. Other distinguishing features are the large size, broadly sloping lateral slopes, slightly differentiated auricula-

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EXPLANATION OF PLATE 66

Figures natural size unless otherwise indicated. U.I. indicates University of Illinois collections; W.M. indicates Walker Museum, University of Chicago collections.

FIGS. *1–7*—Genus *Echinoconchus* Weller (p. 555)

1–4, Echinoconchus alternatus (Norwood and Pratten). *1*, Interior of brachial valve of specimen, Keokuk limestone, Warsaw, Ill., U.I. E-658. *2*, *3*, Lateral and pedicle views of another specimen, showing the several rows of spines on each band, Keokuk limestone, Canton, Mo., U.I. E-2148. *4*, Mold of the exterior of a brachial valve; U.I. E-2148.

5–7, Echinoconchus biseriatus (Hall), Salem limestone, Spergen Hill, Ind.; pedicle, brachial, and lateral views of a hypotype, W.M. 14315.

8–10—Genus *Pustula* Thomas (p. 554)

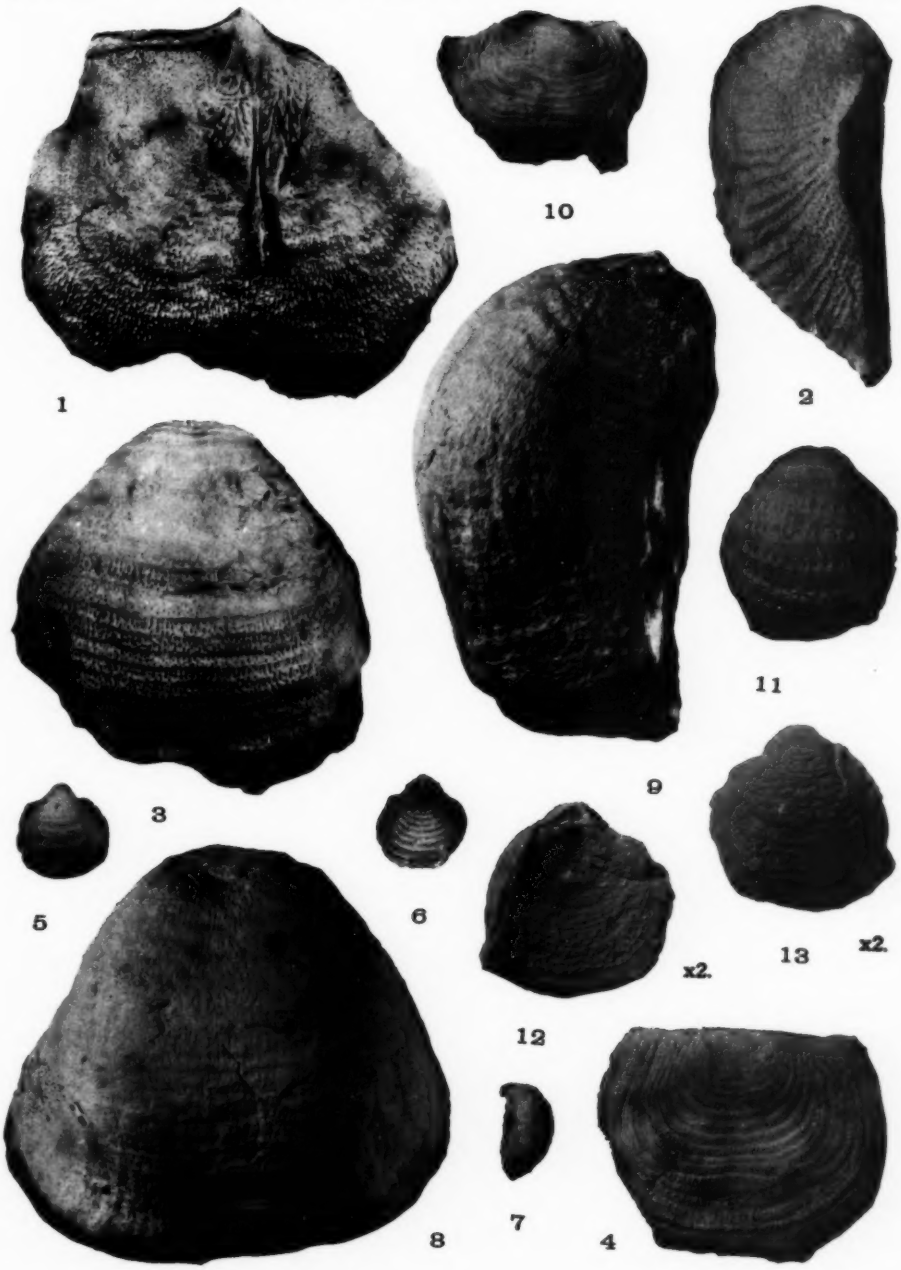
8, 9, Pustula pustulosa (Phillips), Lower Carboniferous, Millicent, Ireland; pedicle and lateral views of specimen, showing the single row of spines on each band; U.I. E-2329.

10, Pustula mesoloba (Phillips), Lower Carboniferous, Settle, Yorkshire, England; mold of brachial valve, W.M. 12763.

11—Overtonia fimbriata (Sowerby), Lower Carboniferous, Yorkshire, England, W.M. 12751. This genus is not known to be represented in North America, illustration of this species being included here to show similarity of surface ornamentation to that of *Pustula*, from which it is reported to differ only in the character of the brachial impressions.

12, 13—Genus *Krotowia* Fredericks (p. 557)

12, 13, Krotowia echinata (Moore), ————————————; brachial and pedicle views of a syntype, ×2, W.M. 9825.



Sutton, Mississippian Brachiopoda (Productidae)

UNIV. OF MICH.

tions, groups of spines on the auriculations, and the slightly protuberant umbo. Only one species of this genus is known.

Genotype, *Productus magnus* Meek and Worthen.

MARGINIRUGUS MAGNUS
(Meek and Worthen)
Plate 63, figures 10–13

Productus magnus MEEK AND WORTHEN, *1861*, Acad. Nat. Sci. Philadelphia, Proc., p. 142; *1868*, Illinois Geol. Survey, vol. 3, p. 528, pl. 20, figs. 7a–c.—KEYES, *1894*, Missouri Geol. Survey, vol. 5, p. 41.—WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 117, pl. 15, figs. 1–8.—GIRTY, *1929*, U. S. Geol. Survey, Prof. Paper 154-B, p. 82, pl. 9, figs. 11, 12.

Productus fentonensis SWALLOW, *1863*, St. Louis Acad. Sci. Trans., vol. 2, p. 93.

Genus MARGINIFERA Waagen, 1884
(See plate 64, figures 14–17; text figure 1*e*)

Small productids with reticulate umbones, relatively long hinge lines, and an internal flangelike ridge that rises from the margin of the visceral disc of the brachial valve. A similar ridge may develop incipiently around the posterolateral margin of the visceral portion of the pedicle valve. Shells costate in all growth stages. Erect spines on the pedicle valve and occasionally on the brachial.

Genotype, *Marginifera typica* Waagen.

Remarks.—Muir-Wood (1930, p. 103) proposed the generic name *Eomarginifera* for British Lower Carboniferous species with a similar ridge. In her diagnosis she stressed the incipient development of the marginal ridge around the brachial disc as distinguished from *Marginifera*, but this distinction of degree does not seem to be a valid criterion for generic differentiation. Some of the Pennsylvanian species of *Marginifera* do not have this ridge strongly developed. On the other hand, certain specimens of the only described Mississippian species, *M. adairensis*, possess a ridge that is as well developed as in some of the Pennsylvanian species. Because of this fact, the Mississippian species is assigned to *Marginifera* rather than *Eomarginifera*. I do not believe that forms should be assigned to different genera simply because some occur in Mississippian (Lower Carboniferous) and others in higher strata, and I question the validity of *Eomarginifera* because it was based on a difference in degree of a character and not on a difference in characters.

MARGINIFERA ADAIRENSIS Drake

Productus (*Marginifera*) *adairensis* DRAKE, *1898*, Am. Phil. Soc., Proc., vol. 36, no. 156, p. 402, pl. 9, figs. 1–3; *1898*, Hopkins Seaside Lab. Control. Biol. no. 14, p. 402, pl. 9, figs. 1–3 (Reprint).

Productus adairensis Drake, GIRTY, *1915*, U. S. Geol. Survey, Bull. 593, p. 50, pl. 3, fig. 6.

Marginifera adairensis (Drake), SNIDER, *1915*, Oklahoma Geol. Survey, Bull. 24, pt. 2, p. 84, pl. 4, figs. 12–14.

Eomarginifera aff. adairensis (Drake), HERNON, *1935*, Jour. Paleontology, vol. 9, no. 8, p. 679.

Genus MARGINICINCTUS Sutton, n. gen.
(See plate 63, figures 5–9; text figure 1*f*)

Shell geniculate, typically productid in character, with gibbous pedicle valve and a brachial valve that is flat or only slighly concave. Beyond the geniculation the two valves continue nearly in contact to form a relatively short trail. Auriculations present on pedicle valve. Posterior portion of pedicle valve and most of brachial valve marked by concentric wrinkles or rugae. Both valves marked by radiating costae, which increase by bifurcation and intercalation. The most distinctive feature of this genus, and the one which serves to separate it from all other productids, is a conspicuous ringlike border around the lateral and anterior portions of the pedicle valve, beginning just posterior to the plane of the brachial disc.

Genotype, *Productus, marginicinctus* Prout.

Remarks.—Some productids have the margins of the pedicle valve characterized by conspicuous flaring, such as *Thomasella* Fredericks (none known from

American Mississippian), but no other possesses a pedicle valve that flares or is deflected, convexly curved and then inflected to form such a conspicuous ring or inrolled border. Two described Mississippian species, one from the Keokuk and one from the St. Louis limestone are known. I have seen one specimen, an unnamed species of this genus from the McLeansboro (Pennsylvanian) formation of Illinois.

MARGINICINCTUS MARGINICINCTUS (Prout)

Plate 63, figures 5–8

Productus marginicinctus PROUT, *1857*, St. Louis Acad. Sci., Trans., vol. 1, p. 43, pl. 2, figs. 1–16.—HALL, *1858*, Geol. Iowa, vol. 1, pt. 2, p. 674, pl. 24, figs. 3a–d.—KEYES, *1894*, Missouri Geol. Survey, vol. 5, p. 43.—WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 127, pl. 13, figs. 18–23.

MARGINICINCTUS WORTHENI (Hall)

Plate 63, figure 9

Productus wortheni HALL, *1858*, Geol. Iowa, vol. 1, pt. 2, p. 635, pl. 19, figs. 1a–b.—WELLER, Illinois Geol. Survey, Mon. 1, p. 126, pl. 13, figs. 13–17.

Genus DICTYOCLOSTUS Muir-Wood, 1930

(See plate 64, figures 1–8; text figure 1*b*, *c*)

Shell subquadrate or somewhat elongate in outline, with the hinge line moderately long. Pedicle valve strongly convex and usually geniculate. Brachial valve somewhat concave or flat over the visceral disc and then geniculate. Visceral cavity medium to deep. Trail short or medium. Surface costate in all growth stages. Visceral disc of both valves with numerous concentric rugae, which are enlarged where they cross the costae to form a characteristic netlike reticulated ornamentation. No diaphragm or marginal ridge around the brachial disc. No hinge teeth or sockets. Cardinal process strong. Occasionally a linear cardinal area occurs.

Genotype, *Anomites semireticulatus* Martin.

Remarks.—Dictyoclostus is probably the most characteristic genus of the Productidae and the one which most people consider as typical *Productus*. It is also probably the most important numerically and ranges through the Mississippian, Pennsylvanian, and Permian, in contrast to *Productus* which, as far as now known, is confined to later Mississippian (Lower Carboniferous) strata.

DICTYOCLOSTUS ARCUATUS (Hall)

Productus arcuatus HALL, *1858*, Geol. Iowa, vol. 1, pt. 2, p. 518, pl. 7, figs. 4a–b.—HERRICK, *1888*, Denison Univ., Sci. Lab., Bull., vol. 3, p. 31, pl. 3, fig. 18.—KEYES, *1894*, Missouri Geol. Survey, vol. 5, p. 40.—WELLER, *1901*, St. Louis Acad. Sci., Trans., vol. 11, p. 160, pl. 14, figs. 23, p. 185, pl. 16, fig. 15; *1914*, Illinois Geol. Survey, Mon. 1, p. 107, pl. 14, figs. 1–7.—MOORE, *1928*, Missouri Bureau Geol. and Mines, 2nd ser., vol. 21, p. 265.

Producta arcuata (Hall), WINCHELL, *1870*, Am. Philos. Soc., Proc., vol. 11, p. 250.

Productella arcuata (Hall), HALL, *1883*, Rept. New York State Geologist for 1882, pl. 48 (17), figs. 31, 32.—HALL AND CLARKE, *1892*, Paleontology New York, vol. 8, pt. 1, pl. 17, figs. 31, 32.

Avonia arcuata (Hall), GIRTY, *1915*, Missouri Bureau Geol. and Mines, 2nd ser., vol. 13, p. 249.

DICTYOCLOSTUS BURLINGTONENSIS (Hall)

Productus flemingi var. *burlingtonensis* HALL, *1858*, Geol. Iowa, vol. 1, pt. 2, p. 598, pl. 12, figs. 3a–g; *1883*, Rept. New York State Geologist for 1882, pl. 49 (18), figs. 6–8.—HALL AND CLARKE, *1892*, Paleontology New York, vol. 8, pt. 1, pl. 18, figs. 6–8.

Productus burlingtonensis Hall, KEYES, *1894*, Missouri Geol. Survey, vol. 5, p. 41.—WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 104, pl. 9, figs. 1–10.—GIRTY, *1915*, U. S. Geol. Survey, Bull. 598, p. 14; 1929, U. S. Geol. Survey, Prof. Paper 154B, p. 85, pl. 9, figs. 20–24.

DICTYOCLOSTUS CALHOUNENSIS (Moore)

Productus calhounensis MOORE, *1928*, Missouri Bureau Geol. and Mines, 2nd ser., vol. 21, p. 266, pl. 10, figs. 1–6.

DICTYOCLOSTUS CRAWFORDSVILLENSIS (Weller)

Plate 64, figures 5–8

Productus magnus [not Meek and Worthen] HALL AND CLARKE, *1892*, Paleontology New York, vol. 8, pt. 1, pl. 17A, fig. 15.

Productus crawfordsvillensis WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 116, pl. 12, figs. 4–7.—GIRTY, *1929*, U. S. Geol. Survey, Prof. Paper 154B, pp. 83–84, pl. 9, figs. 13, 14.

DICTYOCLOSTUS FERNGLENENSIS (Weller)

Productus fernglenensis WELLER, *1909*, Geol. Soc. America, Bull., vol. 20, p. 299, pl. 12, figs. 14–17; *1914*, Illinois Geol. Survey, Mon. 1, p. 106, pl. 9, figs. 11–17.—BUTTS, *1926*, Alabama Geol. Survey, Special Rept. 14, pl. 54, figs. 22–24.

DICTYOCLOSTUS SEDALIENSIS (Weller)

Productus blairi MILLER, *1891*, Indiana Geol. Survey, Adv. Sheets, 17th Rept., p. 79, pl. 13, fig. 17 (not fig. 16); *1892*, Indiana Geol. Survey, 17th Rept., p. 689, pl. 13, fig. 17 (not fig. 16).

Productus sedaliensis WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 108, pl. 14, figs. 1–7.

DICTYOCLOSTUS INFLATUS (McChesney)

Productus inflatus McCHESNEY, *1859*, Descr. New Fossils, p. 40; *1865*, Ill. New Spec. Fossils, pl. 6, figs. 1a–c; *1868*, Chicago Acad. Sci., Trans., vol. 1, p. 27, pl. 6, figs. 1a–c.—WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 111, pl. 10, figs. 1–6.—SNIDER, *1915*, Oklahoma Geol. Survey, Bull. 24, pt. 2, p. 78.—BUTTS, *1926*, Alabama Geol. Survey, Spec. Rept. 14, pl. 61, fig. 13.—WELLER, J. M., *1931*, Kentucky Geol. Survey, Symposium, p. 288, pl. 43, figs. 6a–b.—HERNON, *1935*, Jour. Paleontology, vol. 9, no. 8, p. 681.

DICTYOCLOSTUS MESIALIS (Hall)
Plate 64, figures 1–4

Productus mesialis HALL, *1858*, Geol. Iowa, vol. 1, pt. 2, p. 639, pl. 19, figs. 2a–c; *1883*, Rept. New York State Geologist for 1882, pl. 49 (18), figs. 9, 10.—HALL AND CLARKE, *1892*, Paleontology New York, vol. 8, pt. 1, pl. 18, figs. 9, 10.—WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 112, pl. 10. figs. 7–13; pl. 83, figs. 14–17.—GIRTY, *1929*, U. S. Geol. Survey, Prof. Paper, 154B, pp. 84–85, pl. 9, figs. 15–19.

DICTYOCLOSTUS MESICOSTALIS (Weller)

Productus mesicostalis WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 114, pl. 11, figs. 12–16.

DICTYOCLOSTUS COLORADOENSIS (Girty)

Productus boliviensis (not d'Orbigny) NIKITIN, *?1890*, Com. géol. (Russia), Mém., vol. 5, p. 57, pl. 1, figs. 4a–c.

Productus inflatus (not McChesney) TSCHERNYCHEW, *?1902*, Com. géol. (Russia), Mém., vol. 16, no. 2, p. 261, pl. 28, figs. 1–6.—GIRTY, *1903*, U. S. Geol. Survey, Prof. Paper 16, p. 359, pl. 3, figs. 1–1b, 2, 2a, 3; *1904*, U. S. Geol. Survey, Prof. Paper 21, p. 52, pl. 11, figs. 5, 6.

Productus inflatus var. *coloradoensis* GIRTY, *1910*, N. Y. Acad. Sci., Annals, vol. 20, no. 3, pt. 2, p. 215; *1911*, U. S. Geol. Survey, Bull. 439, p. 42, pl. 4, fig. 3; *1915*, U. S. Geol. Survey, Bull. 593, p. 47, pl. 3, figs. 7–8a.

Productus coloradoensis Girty, SNIDER, *1915*, Oklahoma Geol. Survey, Bull. 24, pt. 2, p. 80.

DICTYOCLOSTUS CHEROKEENSIS (Drake)

Productus cherokeensis DRAKE, *1898*, Hopkins Seaside Lab. Contr. Biol. no. 14, p. 404, pl. 9, figs. 4, 5. (Also, Am. Philos. Soc., Proc., vol. 36, no. 156.)—SNIDER, *1915*, Oklahoma Geol. Survey, Bull. 24, pt. 2, p. 80, pl. 3, figs. 22–24.

Productus inflatus var. *clydensis* GIRTY, *1910*, N. Y. Acad. Sci., Annals, vol. 20, no. 3, pt. 2, p. 215.

DICTYOCLOSTUS PARVUS (Meek and Worthen)

Productus parvus MEEK AND WORTHEN, *1860*, Acad. Nat. Sci. Philadelphia, Proc., p. 450; *1866*, Illinois Geol. Survey, vol. 2, p. 297, pl. 23, figs. 4a–e.—HERRICK, Denison Univ. Sci. Lab., Bull., vol. 4, pl. 11, fig. 11.—WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 121, pl. 16, figs. 16–22.

DICTYOCLOSTUS CURTIROSTRIS (Winchell)

Producta curtirostra WINCHELL, *1865*, Acad. Nat. Sci. Philadelphia, Proc., p. 114.

Productus semireticulatus (Martin), WELLER, *1900*, St. Louis Acad. Sci., Trans., vol. 10, p. 70, pl. 1, figs. 7–8.

Productus curtirostris (Winchell), WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 130, pl. 14, figs. 8–13.

Pustula? curtirostris (Winchell), GIRTY, *1915*, Missouri Bureau Geol. and Mines, vol. 13, 2nd ser., p. 248.

DICTYOCLOSTUS GALEANUS (Girty)

Productus galeanus GIRTY, *1927*, U. S. Geol. Survey, Prof. Paper 152, p. 412, pl. 22, figs. 27–32.

DICTYOCLOSTUS RICHARDSI (Girty)

Productus richardsi GIRTY, *1927*. U. S. Geol. Survey, Prof. Paper 152, p. 414, pl. 23, figs. 7–19.

DICTYOCLOSTUS SCITULUS (Meek and Worthen)

Productus scitulus MEEK AND WORTHEN, *1860*, Acad. Nat. Sci. Philadelphia, Proc., p. 451; *1866*, Illinois Geol. Survey, vol. 2, p. 280, pl. 20, figs. 5a–d.—WELLER, Illinois Geol. Survey, Mon. 1, p. 120, pl. 13, figs. 24–29.

DICTYOCLOSTUS PARVIFORMIS (Girty)

Productus parvus [not Meek and Worthen] WHITE, *1875*, U. S. Geol. Surveys W. 100th Mer., Rept., vol. 4, p. 83, pl. 5, figs. 6a, 6d.

Productus parviformis GIRTY, U. S. Geol. Survey, Mon. 32, pt. 2, p. 536, pl. 68, fig. 6.

Genus BUXTONIA Thomas, 1914 (emend. Muir-Wood, 1928)

(See plate 65, figures 1–7)

Shell normally large. Pedicle valve convex, rarely geniculate; brachial valve flat or slightly concave, forming a rather large visceral cavity, although not as large as in several other genera of the Productinae. Shell ornamented with costae over the entire length. Scattered elongate spine bases occur on the costae in young and adult individuals. Often there are groups of spines just inside the auriculations of the pedicle valve. In old age, bands with numerous spine bases are often developed around the anterior portion of the pedicle valve. Rugae on the ears and posterior portions of the umbonal slopes. The chief distinguishing feature of this genus is the character of the costae and associated spines.

Genotype, *Productus scabriculus* (Martin).

BUXTONIA ARIZONENSIS Hernon

Buxtonia arizonensis HERNON, *1935*, Jour. Paleontology, vol. 9, no. 8, p. 681, pl. 81, figs. 1a–c.

BUXTONIA NEWTONENSIS (Moore)

Productus newtonensis MOORE, *1928*, Missouri Bur. Geol. and Mines, 2nd ser., vol. 21, p. 267, pl. 10, figs. 12–13.

BUXTONIA SEMICIRCULARIS (Sutton and Wagner)

Plate 65, figure 1

Productus semicircularis SUTTON AND WAGNER, *1931*, Jour. Paleontology, vol. 5, no. 1, p. 23, pl. 5, figs. 20–22.

BUXTONIA INCURVATA (Sutton and Wagner)

Plate 65, figure 5

Productus incurvatus SUTTON AND WAGNER, *1931*, Jour. Paleontology, vol. 5, no. 1, p. 26, pl. 5, figs. 18–19.

BUXTONIA ARKANSANA (Girty)

Productus arkansanus GIRTY, *1910*, New York Acad. Sci. Annals, vol. 20 no. 3, pt. 2, p. 216; *1915*, U. S. Geol. Survey, Bull. 593, p. 46, pl. 2, figs. 5–7.—SNIDER, *1915*, Oklahoma Geol. Survey, Bull. 24, pt. 2, p. 81, pl. 3, figs. 1–3.

Productus abruptus SUTTON AND WAGNER, *1931*, Jour. Paleontology, vol. 5, no. 1, p. 24, pl. 5, figs. 15–17.

Avonia? arkansana (Girty) GIRTY, *1915*, Missouri Bureau Geol. and Mines, 2nd ser., vol. 13, p. 349.

Buxtonia arkansana (Girty) HERNON, *1935*, Jour. Paleontology, vol. 9, no. 8, p. 681.

BUXTONIA MULTILIRATA (Girty)

Productus arkansanus var. *multiliratus* GIRTY, *1910*, New York Acad. Sci., Annals, vol. 20, no. 3, pt. 2, p. 217; *1911*, U. S. Geol. Survey, Bull. 439, p. 43, pl. 2, figs. 10–11.

Avonia? arkansana var. *multilirata* (Girty) GIRTY, *1915*, Missouri Bur. Geology and Mines, 2nd ser., vol. 13, p. 349; *1929*, U. S. Geol. Survey, Prof. Paper 154B, p. 86, pl. 9, fig. 25.

BUXTONIA VIMINALIS (White)

Plate 65, figure 6

Productus setigerus? var. *keokuk* HALL, *1858*, Geol. Iowa, vol. 1, pt. 2, p. 639, pl. 19, figs. 4b, c.

Productus viminalis WHITE, *1862*, Boston Soc. Nat. Hist., Proc., vol. 9, p. 29.—WELLER, Illinois Geol. Survey, Mon. 1, p. 114, pl. 11, figs. 6–11.

Productus semireticulatus (Martin) HALL, *1863*, Rept. New York State Geologist for 1882, pl. 49 (18), fig. 12 (not figs. 11,13).—HALL AND CLARKE, *1892*, Paleontology New York, vol. 8, pt. 1, pl. 18, fig. 12 (not figs. 11, 13).

BUXTONIA SETIGERA (Hall)

Productus setigerus HALL, *1858*, Geol. Iowa, vol. 1, pt. 2, p. 638, pl. 19, fig. 3.—WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 122, pl. 12, figs. 1–3.

Productus semireticulatus (Martin) HALL, *1883*, Rept. New York State Geologist for 1882, pl. 49 (18), fig. 13 (not figs. 11, 12).—HALL AND CLARKE *1892*, Paleontology New York, vol. 8, pt. 1, pl. 18, fig. 13 (not figs. 11, 12).

Genus AVONIA Thomas, 1914
(emend. Muir-Wood, 1928)
(See plate 62, figures 7–15)

Productids characterized in early stages by spinosity alone, later developing costae. Phylogerontic individuals may be smooth. Pedicle valve evenly convex; brachial valve moderately concave, forming a medium, uniform visceral cavity that occupies the whole length of the shell. Median sinus absent. Concentric rugae on the posterior portion of the shell, ill defined toward the middle portion. Shell subequal, length usually a little greater than width. Hinge line may be equal to greatest width but is usually shorter. Marginal ridges short, diverging from the hinge line. Cardinal process small, median septum narrow and adductor scars not dendritic.

Genotype, *Productus youngianus* T. Davidson.

Remarks.—This genus differs from *Protoniella* Bell only in the presence of a cicatrix of attachment in the latter, a feature which is not considered of taxonomic value.

In *Avonia* are placed three species, *A. laevicula* (Moore), *A. incrassata* (Girty), and *A. indianensis* (Hall), none of which possess costae on the anterior portion of the shell. These are all very small species which are believed to represent forms that, because of local environmental factors or other causes, never attained the normal size of the genus. Some workers have assigned them to *Pustula*, but they are not so treated here because they lack concentric bands. They do not belong to *Krotovia* because of their very sparsely developed spines, in contrast to the closely spaced spines of *Krotovia*. If they are not classified with *Avonia* a new genus must be erected for them. It is believed that these forms, had they attained larger size, might have developed costae, and because of this fact are retained in *Avonia*. *A. newarkensis* (Moore) has very slightly developed costae.

Most species of *Avonia* have more or less irregularly and sparsely distributed spines on the posterior portion of the valve, but *A. millespinosa* possesses rather numerous spines arranged in definite concentric rows, which is suggestive of the arrangement of spines in *Pustula*. The spines are not on concentric bands, however, and the shell possesses well defined costae on the anterior portion of the shell. *A. blairi* is another species that differs somewhat from the normal type. In this species the costae of the pedicle valve are discontinuous or interrupted, and appear as elongate nodes. The radial markings of the brachial valve consist of a series of elongate pits. This feature has been so emphasized in previous descriptions that other characters have been overlooked. It seems to fit best in *Avonia*.

AVONIA PUSTULIFERA Moore
Plate 62, figures 12–15

Avonia pustulifera MOORE, *1928*, Missouri Bur. Geology and Mines, 2nd ser., vol. 21, p. 271, pl. 11, figs. 7, 11, 12, 16, 17, 20, 21.

AVONIA? LAEVICULA (Moore)

Pustula laevicula MOORE, *1928*, Missouri Bur. Geology and Mines, 2nd ser., vol. 21, p. 268, pl. 11, figs. 22–27.

AVONIA? INCRASSATA (Girty)

Pustula incrassata GIRTY, *1929*, U. S. Geol. Survey, Prof. Paper 154B, p. 86, pl. 9, figs. 7–9.

AVONIA MOOREFIELDANA (Girty)

Productus moorefieldanus GIRTY, *1911*, U. S. Geol. Survey, Bull. 439, p. 48, pl. 3, fig. 6.
Pustula moorefieldana (Girty) SNIDER, *1915*, Oklahoma Geol. Survey, Bull. 24, pt. 2, p. 82.—GIRTY, *1915*, Missouri Bur. Geology and Mines, vol. 13, 2nd ser., p. 348.

AVONIA OKLAHOMENSIS Snider
Plate 62, figures 9–11

Avonia oklahomensis SNIDER, *1915*, Oklahoma Geol. Survey Bull. 24, pt. 2, p. 83, pl. 4, figs. 4–11.

AVONIA? INDIANENSIS (Hall)
Plate 62, figures 7, 8

Productus indianensis HALL, *1856*, Albany Inst., Trans., vol. 1, p. 47.—WHITFIELD, *1882*, Am. Mus. Nat. Hist., Bull., vol. 1, p. 47, pl. 6, figs. 6, 7.—HALL, *1883*, Indi-

ana Geol. Survey, 12th Rept., p. 326, pl. 29, figs. 6, 7.—BEEDE, *1906*, Indiana Geol. Survey, 30th Ann. Rept., p. 1300, pl. 19, figs. 7, 7a; pl. 22, figs. 6, 7.—WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 131, pl. 83, figs. 12, 13.

Pustula indianensis (Hall) GIRTY, *1915*, Missouri Bur. Geology and Mines, vol. 13, 2nd ser., p. 348.

AVONIA CONCENTRICA (Hall)

Productus concentricus HALL, *1857*, New York State Cab. Nat. Hist., 10th Rept. p. 180; *1858*, Geol. Iowa, vol. 1, pt. 2, p. 517, pl. 7, fig. 3.—HERRICK, *1888*, Denison Univ., Sci. Lab. Bull., vol. 3, p. 33, pl. 6, fig. 16.

Productus shumardianus HALL, *1858*, Geology Iowa, vol. 1, pt. 2, p. 499, pl. 7, fig. 1 (not pl. 3, fig. 9).

Productus cooperensis SWALLOW, *1860*, St. Louis Acad. Sci., Trans., vol. 1, p. 640.

Producta concentrica (Hall) WINCHELL, *1862*, Acad. Nat. Sci. Philadelphia, Proc., p. 411; *1865*, Idem., p. 114; *1869*, Safford's Geology of Tennessee, p. 443; 1870, Am. Philos. Soc., Proc., vol. 11, p. 249.

Producta cooperensis (Swallow), WINCHELL, *1865*, Acad. Nat. Sci. Philadelphia, Proc., p. 115.

Productella shumardiana (Hall) HALL, *1867*, Paleontology New York, vol. 4, p. 157, pl. 23, figs. 6–8.—HALL AND CLARKE, *1892*, Paleontology New York, vol. 8, pt. 1, pl. 17, fig. 7.

Productus (*Productella*) *shumardianus* Hall HERRICK, *1888*, Denison Univ., Sci. Lab. Bull., vol. 3, p. 32, pl. 7, fig. 18; pl. 12, figs. 6, 43.

Productella cooperensis (Swallow) GIRTY, *1899*, U. S. Geol. Survey, Mon. 32, p. 528, figs. 8a–c, 9a–b.

Productella concentrica (Hall) WELLER, *1901*, St. Louis Acad. Sci., Trans., vol. 11, p. 184, pl. 16, figs. 12–14; *1914*, Illinois Geol. Survey, Mon. 1, p. 98, pl. 19, figs. 22–34.

AVONIA SEMICOSTATA (Girty)

Productella semicostata GIRTY, *1915*, U. S. Geol. Survey, Bull. 598, p. 12, pl. 1, figs. 6–6d, 7–7c.

AVONIA MILLESPINOSA (Girty)

Productella millespinosa GIRTY, *1915*, U. S. Geol. Survey, Bull. 598, p. 14, pl. 1, figs. 5–5c.

AVONIA WILLIAMSANA Girty

Avonia williamsana GIRTY, *1931*, Washington Acad. Sci., Jour., vol. 21, no. 16, p. 394, pl. 1, figs. 15–19.

AVONIA NEWARKENSIS (Moore)

Productella concentrica (Hall) GIRTY, *1915*, U. S. Geol. Survey, Bull. 598, p. 11, pl. 1, figs. 3, 3a, 3b.

Pustula newarkensis MOORE, *1928*, Missouri Bur. Geology and Mines, 2nd ser., vol. 21, p. 270, pl. 11, figs. 8–10, 15, 18, 19.

AVONIA BLAIRI (MILLER)

Productus blairi MILLER, *1891*, Indiana Geol. Survey, 17th Rept., Adv. Sheets, p. 79, pl. 13, fig. 16 (not fig. 17); *1892*, Indiana Geol. Survey, 17th Rept., p. 689, pl. 13, fig. 16 (not fig. 17).—WELLER, *1914*, Illinois Geol. Survey, Mon. 1, p. 110, pl. 14, figs. 14–21.

Avonia? blairi (Miller) GIRTY *1915*, Missouri Bur. Geology and Mines, 2nd ser., vol. 13, p. 349.

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LOWER EOCENE OSTRACODA OF THE GENUS CYTHERIDEA FROM ALABAMA

MORTON B. STEPHENSON

ABSTRACT

The finer characters of shell structure of seventeen species of the ostracode genus *Cytheridea*, eight of which are new, are described and figured from the Sabine (Wilcox) and Midway groups of the lower Eocene of Alabama. The species are assigned to the subgenera *Haplocytheridea*, *Clithrocytheridea*, and *Leptocytheridea*.

A number of species belonging to the ostracode genus *Cytheridea* have been described from Tertiary sediments of the Gulf Coast during the past few years. Notable among publications on the Ostracoda of the lower Eocene are those of Howe and Garrett (1934), on the Sabine (Wilcox) of Louisiana, and an excellent paper by Alexander (1934), on the Midway of Texas.

In the summer of 1935, I made a detailed comparative study of type specimens of species of *Cytheridea* recorded from the Sabine of Louisiana by Howe and Garrett, and material from the type section of the Sabine in Alabama.[1] This study has been extended to include several species from the Midway of Alabama, and the finer characters of shell structure noted are here described.

The term, Sabine group, as used in this report, is identical with that used by Howe (1933, pp. 617–621), and later by Howe and Garrett (1934) in describing a number of Ostracoda from Louisiana and Texas. The name was introduced in a report by Veatch (1905), where he stated in a footnote that it was

> Adopted to supplant the name Lignitic. Name taken from typical fossiliferous development of this formation on the Sabine River, in Sabine County, Texas and Sabine Parish, Louisiana.

The following year, Veatch (1906) recognized four substages of the Sabine as follows, from oldest to youngest: (1) Nanafalia, (2) Bells and Greggs landings (Tuscahoma), (3) Woods Bluff, and (4) Hatchetigbee. These four substages or formations have been recognized by Cooke (1926) in the stratigraphic terminology of Alabama, although they are described under the heading of "Wilcox group." The present use of the term Sabine group is, then, in keeping with that of Veatch, and of Howe and Garrett, and embraces the Alabama formations included by the latter authors under their "Wilcox sub-group." The Sabine microfossils here described are most frequently identified by economic paleontologists with strata which they are accustomed to refer to the Wilcox group, a term invalidated by lack of priority.

Zonation of the Sabine group of the Gulf Coast through the use of the ostracode genus *Cytheridea* is difficult, although the very fossiliferous Nanafalia horizon is distinct. The accompanying range chart (p. 571) indicates existence of a moderately distinct faunal break between upper and lower Sabine, as well as an increase in fauna in the Nanafalia formation. The Ostracoda of the overlying Claiborne (Eocene) group of the Gulf Coast are at present inadequately described. The Sabine Ostracoda within the genus *Cytheridea*, however, may be differentiated readily from those of the Jackson (upper Eocene) group. A previous study by me (Stephenson, 1937)

[1] The type section of the Sabine is in Louisiana or Texas; the type sections of the Wilcox group are in Alabama. ED.

has shown that a definite zonation of the Jackson may be made on the basis of species of *Cytheridea*. The present work has indicated that none of the species of *Cytheridea* occurring in the Sabine appear to have survived into Jackson times.

I am deeply indebted to Dr. Henry V. Howe, Director of the School of Geology, Louisiana State University, for making available to me type specimens of Sabine Ostracoda, for supplying the samples upon which this report is based, and for his helpful criticism of the manuscript. Thanks are due Dr. C. I. Alexander, Magnolia Petroleum Company, Lake Charles, La., who kindly forwarded me topotype specimens of *Cytheridea ruida* Alexander.

The type specimens of new species described, together with figured hypotypes of previously described species, have been deposited in the Henry V. Howe collection, Louisiana State University, Baton Rouge, La. The localities from which specimens were collected for this study are described below.

SYSTEMATIC DESCRIPTIONS

Family CYTHERIDAE Baird, 1850

Genus CYTHERIDEA Bosquet, 1852

Subgenus HAPLOCYTHERIDEA Stephenson, 1936

CYTHERIDEA (HAPLOCYTHERIDEA) HARRISI Stephenson, n. sp.

Plate 67, figures 11, 12;
text figures 23, 24

Carapace heavy, tumid; in side view elongate, subovate, greatest height at the anterior one-third of shell length. Dorsal margin gently arched, flattened along the hinge line, subparallel to the ventral margin, which is slightly sinuate. Anterior end obliquely rounded, posterior end narrower and steeply truncated to the rounded postero-ventral angle. Surface sculpture pronounced, consisting of numerous rounded, curvilinear ridges more or less parallel to the outer periphery, and tending to become obscure as they approach it. The furrows, thus formed, contain shallow pits of moderate size, around which short branches of the

RANGE OF LOWER EOCENE OSTRACODA OF THE GENUS CYTHERIDEA FROM ALABAMA

SUBGENUS AND SPECIES	HATCHETIGBEE	BASHI	TUSCAHOMA	NANAFALIA	NAHEOLA MIDWAY
CLITHROCYTHERIDEA TOMBIGBEENSIS	■	■			
LEPTOCYTHERIDEA ALABAMIENSIS	■	■			
HAPLOCYTHERIDEA VEATCHI	■	■	■	■	
CLITHROCYTHERIDEA BROUSSARDI	■	■	■	■	
" PENDLETONENSIS	■	■	■	■	
LEPTOCYTHERIDEA BASHIENSIS	■	■		■	
HAPLOCYTHERIDEA WALLACEI	■			■	
" MOODYI		■		■	
CLITHROCYTHERIDEA TUSCAHOMENSIS			■		
HAPLOCYTHERIDEA HARRISI			■	■	
" SABINENSIS			■	■	
CLITHROCYTHERIDEA NANAFALIENSIS			■	■	
LEPTOCYTHERIDEA HOPKINSI			■	■	
HAPLOCYTHERIDEA LEEI				■	
" MARTHAVILLENSIS				■	
CLITHROCYTHERIDEA ALEXANDERI					■
LEPTOCYTHERIDEA NAHEOLENSIS					■

ridges tend to coalesce. Interior smooth, showing numerous small, deep pits. Hinge in the right valve consists of poorly defined, faintly notched dental areas, connected by the lower, rounded dorsal margin. In the left valve, hinge with notched, well incised terminal sockets, a very faint groove between them, above which the dorsal margin extends as a pronounced ridge. A thickened ventral flange in the left valve, with a strong, depressed lip inside it, is fitted to take the slightly flanged right valve. The lip merges with the steeply shelving marginal end zones, which carry numerous simple radial pore canals. Line of concrescence coincides with the inner margin except on the anterior and posterior, where it is slightly inside it. Muscle-scar pattern a vertical row of four scars, with two elongate scars anterior to them.

Length (right valve) 0.70 mm; height 0.35 mm; length (left valve) 0.67 mm; height 0.35 mm.

Named in honor of G. D. Harris, an early contributor to the paleontology of the Sabine.

Occurrence.—*C.* (*H.*) *harrisi* is very rare in the Sabine. It occurs as single specimens in my collections from Locs. 3, 4, 5, and 6, thus ranging through the Nanafalia and Tuscahoma formations.

Types.—Syntypes, H. V. Howe coll., no. 1456, a right valve from Loc. 5; no. 1457, a left valve from Loc. 6.

CYTHERIDEA (HAPLOCYTHERIDEA)
LEEI Howe and Garrett
Plate 67, figures 4, 5;
Text figures 1, 2

Cytheridea leei HOWE and GARRETT, *1934*, Louisiana Dept. Cons., Geol. Bull. 4, p. 33, pl. 1, figs. 22, 23.

Carapace elongate, subpyriform, highest anterior to the middle. Surface smooth, covered with numerous fine pits. The intensity of surface pitting exhibited by this species is quite variable, some specimens showing pronounced pits over the entire carapace, while on others there is an almost complete absence of pitting. A large suite of specimens shows a gradation in number and prominence of pits, with no abrupt change apparent. It appears impossible to distinguish any specimens possessing varietal characteristics in pitting. Sexual dimorphism is marked, and easily recognizable in the dimensions of the carapace. The greatest height in the male slightly exceeds half the length, while the height of the female is about two-thirds the length. The female carapace is much more broadly rounded, more strongly tumid, and the hinge structure is much heavier. The original description included the hinge, but gave no figures of it, stating that it consisted in the right valve of

> two very small taxodont dental areas connected by a narrow, finely crenulated bar; in the left valve with corresponding indented sockets, connected by a narrow indented furrow, which is bordered above by a narrow bar, which in turn is separated from the dorsal edge by a faint longitudinal depression.

A well incised groove extends above the bar joining the terminal dentitions in the right valve. Muscle scars six in number, four of which are somewhat irregularly placed in a vertical row, with two more oblique and anterior to them. Radial pore canals numerous, straight, simple, about 35 in number on the anterior.

Length (male) 0.69 mm; height 0.39 mm; width 0.30 mm; length (female) 0.75 mm; height 0.48 mm; width 0.40 mm.

Occurrence.—Described from the Nanafalia at Ft. Jessup, La., *C.* (*H.*) *leei* is common at the same horizon in Alabama.

Types.—Hypotypes, H. V. Howe coll., nos. 1442, 1443; other specimens, nos. 1444, 1445. All figured specimens are from Loc. 3.

CYTHERIDEA (HAPLOCYTHERIDEA)
MARTHAVILLENSIS Howe and Garrett
Plate 67, figure 22; text figures 6, 7

Cytheridea marthavillensis HOWE and GARRETT, *1934*, Louisiana Dept. Cons., Geol. Bull. 4, p. 34, pl. 1, figs. 24, 25; pl. 2, fig. 1.

This elongate, smooth species, which is here assigned to the subgenus *Haplocytheridea*, has been well described by the original authors. The hinge (text figs. 6, 7) was characterized as

> slightly incurved, occupying more than one-third of the dorsal margin; in the right valve with two small taxodont dental areas, six times as long as wide and with about six notched dentitions. A narrow, crenulated, connecting bar which slopes off to the dorsal margin connects these dental areas. In the left valve with two large indented, notched sockets connected by a narrow indented furrow, above which is a narrow bar, which is separated from the dorsal margin by a narrow groove.

Marginal areas narrow, with the line of concrescence coinciding with the inner margin. Radial pore canals numerous, about 30 in number on the anterior. Six muscle scars are present, four closely spaced and vertical, two elongate, oblique, and anterior to them.

Length 0.69 mm; height 0.37 mm; width 0.31 mm.

Occurrence.—This species appears to be restricted to the Nanafalia, basal Sabine, in Alabama and Louisiana.

Types.—Hypotypes, H. V. Howe coll., nos. 1447, 1448, 1449, from Loc. 3.

CYTHERIDEA (HAPLOCYTHERIDEA) MOODYI Howe and Garrett

Plate 67, figure 3; text figures 3, 4

Cytheridea moodyi HOWE and GARRETT, *1934*, Louisiana Dept. Cons., Geol. Bull. 4, pp. 35, 36, pl. 2, figs. 2–6.

Carapace subovate, slightly convergent posteriorly, cardinal angles obscure. Surface with pits arranged in transverse curvilinear furrows concave toward a median vertical sulcus. The hinge line, which is typical of the subgenus *Haplocytheridea*, was described by Howe and Garrett as

> almost straight, occupying half the dorsal margin; in the right valve with two raised, taxodont dental areas, the anterior one being somewhat larger, each about eight times as long as wide and with about eight dentitions; dental areas connected by a low narrow, crenulated ridge; hinge in left valve with two indented sockets connected by a narrow, notched, indented area, above which is a narrow ridge, sloping off to the dorsal margin.

Radial pore canals numerous, extending along the entire ventral margin. Muscle-scar pattern consists of four scars in a vertical row, with two more to the anterior.

Length (left valve including spines) 0.90 mm; height 0.47 mm.

Occurrence.—*C.* (*H.*) *moodyi* is very rare at Locs. 3 and 8, the only Alabama stations from which I have obtained specimens. Figured specimens are from the Bashi exposure at Sabinetown, Tex., which were chosen for this study because of their excellent preservation.

Types.—Hypotypes, H. V. Howe coll., nos. 1450, 1451.

CYTHERIDEA (HAPLOCYTHERIDEA) SABINENSIS Howe and Garrett

Plate 67, figure 23; text figures 5, 9, 10, 16

Cytheridea sabinensis HOWE and GARRETT, *1934*, Louisiana Dept. Cons., Geol. Bull. 4, pp. 40–42, pl. 2, figs. 16–20.

This distinctive species has been carefully defined by the original authors, who state that the hinge line (text figs. 9, 10) is

> straight, taking up over one-third of the entire dorsal margin; consisting in the right valve of two taxodont dental areas, each about three times as long as wide and with six or more dentitions, the anterior dental area being somewhat broader and more conspicuous; both dental areas, especially the anterior one, make obtuse angles with the hinge line; dental areas connected by a low, narrow, finely crenulated bar; parallel and adjacent to this is a straight narrow groove, which separates the bar from the dorsal margin. In the left valve the hinge consists of two indented, notched sockets, connected by a more finely notched, narrow, depressed area, above which is a straight narrow bar, which is separated from the dorsal margin

by a marked straight furrow which ends abruptly at the cardinal angles.

Marginal areas moderately broad, with the inner margin coinciding with the line of concrescence throughout. Radial pore canals straight, simple, about 25 in number on the anterior, tending to occur in groups of two or three. Muscle-scar pattern (text fig. 5) typical for the genus, with a vertical row of four scars, and two more anterior to them.

Length 0.65 mm; height 0.42 mm; width 0.35 mm.

Occurrence.—*C.* (*H.*) *sabinensis* is abundant in the lower Sabine (Nanafalia and Tuscahoma) of the Gulf Coast. Previously recorded from Pendleton, Tex., Marthaville and Ft. Jessup, La., and Nanafalia and Bells Landings, Ala., I have found it to be common at Greggs Landing as well.

Types.—Hypotypes, H. V. Howe coll., nos. 1452, 1453, 1454, from Loc. 4.

CYTHERIDEA (HAPLOCYTHERIDEA) VEATCHI Howe and Garrett

Plate 67, figure 6; text figures 25–27

Cytheridea veatchi HOWE and GARRETT, *1934*, Louisiana Dept. Cons., Geol. Bull. 4, pp. 43, 44, pl. 3, figs. 1–4.

Carapace elongate, in side view subquadrate; dorsal margin sloping slightly toward the posterior, ventral margin straight. Anterior end broadly and evenly rounded, posterior end narrower, bluntly and obliquely truncated to the rounded postero-ventral angle. Anterior and posterior ends faintly spinose. Ornamentation consists of rows of deep

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EXPLANATION OF PLATE 67

All figures ×40

FIGS. *1, 2*—*Cytheridea* (*Clithrocytheridea*) *tombigbeensis* Stephenson, n. sp. Lateral view of syntypes; *1*, left valve (no. 1434); *2*, right valve (no. 1435). (p. 579)

3—*Cytheridea* (*Haplocytheridea*) *moodyi* Howe and Garrett. Lateral view, left valve (no. 1450). (p. 573)

4, 5—*Cytheridea* (*Haplocytheridea*) *leei* Howe and Garrett. *4*, Male, right valve view (no. 1442). *5*, Female, right valve view (no. 1443). (p. 572)

6—*Cytheridea* (*Haplocytheridea*) *veatchi* Howe and Garrett. Right valve view (no. 1458). (p. 574)

7, 8—*Cytheridea* (*Leptocytheridea*) *alabamensis* Stephenson, n. sp. Lateral view of syntypes; *7*, left valve (no. 1436); *8*, right valve (no. 1437). (p. 582)

9, 10—*Cytheridea* (*Clithrocytheridea*) *nanafaliensis* Stephenson, n. sp. Lateral view of syntypes; *9*, left valve (no. 1467); *10*, right valve (no. 1468). (p. 578)

11, 12—*Cytheridea* (*Haplocytheridea*) *harrisi* Stephenson, n. sp. Lateral view of syntypes; *11*, left valve (no. 1457); *12*, right valve (no. 1456). (p. 571)

13, 14—*Cytheridea* (*Leptocytheridea*) *hopkinsi* Howe and Garrett. *13*, Male, right valve view (no. 1438). *14*, Female, right valve view (no. 1439). (p. 583)

15, 16—*Cytheridea* (*Clithrocytheridea*) *tuscahomensis* Stephenson, n. sp. *15*, Lateral view of paratype, left valve (no. 1463). *16*, Lateral view of holotype, right valve (no. 1462). (p. 580)

17—*Cytheridea* (*Leptocytheridea*) *bashiensis* Stephenson, n. sp. Lateral view of holotype, left valve (no. 1446). (p. 582)

18—*Cytheridea* (*Clithrocytheridea*) *pendletonensis* Howe and Garrett. Right valve view (no. 1469). (p. 578)

19, 20—*Cytheridea* (*Clithrocytheridea*) *alexanderi* Stephenson, n. sp. *19*, Lateral view of holotype, left valve (no. 1428). *20*, Lateral view of paratype, right valve (no. 1461). (p. 575)

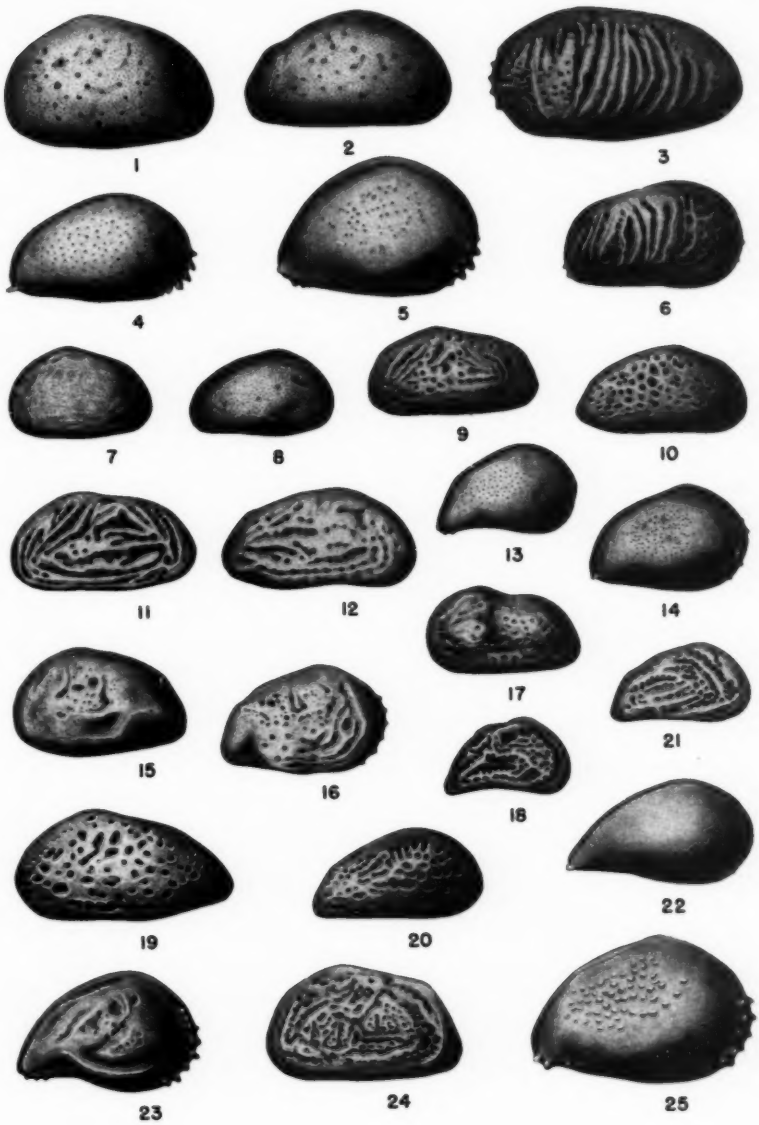
21—*Cytheridea* (*Leptocytheridea*) *naheolensis* Stephenson, n. sp. Lateral view of syntype right valve (no. 1464). (p. 583)

22—*Cytheridea* (*Haplocytheridea*) *marthavillensis* Howe and Garrett. Right valve view (no. 1447). (p. 572)

23—*Cytheridea* (*Haplocytheridea*) *sabinensis* Howe and Garrett. Right valve view (no. 1452). (p. 573)

24—*Cytheridea* (*Clithrocytheridea*) *broussardi* Howe and Garrett. Lateral view, left valve (no. 1432). (p. 576)

25—*Cytheridea* (*Haplocytheridea*) *wallacei* Howe and Garrett. Right valve view (no. 1429). (p. 575)



Stephenson, Tertiary (Eocene) Ostracoda

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pits subparallel to anterior, ventral, and posterior margins, which are separated by narrow, irregular ridges which tend to become beaded on the posterior. The hinge line (text figs. 26, 27), as originally described, is almost straight, consisting in the right valve of

two raised taxodont dental areas, about eight times as long as wide and with about eight dentitions, dental areas connected by a low, narrow, finely crenulated bar, which slopes off sharply to the dorsal margin; hinge in the left valve with indented sockets and a connecting, narrow, indented, notched furrow, having above it a narrow bar, which slopes off sharply to the dorsal margin.

Marginal areas narrow, with the line of concrescence slightly inside the inner margin on the anterior and posterior. Radial pore canals simple, about 35 on the anterior. Muscle-scar pattern (text fig. 26) typical for the genus.

Length 0.64 mm; height 0.37 mm; width 0.31 mm.

Remarks.—This species is readily distinguished from *C.* (*H.*) *leei*, with which it often occurs, by the alternating rows of pitted furrows and ridges, and its quadrate outline. The straight ventral margin usually separates it from *C.* (*H.*) *moodyi*, and Howe and Garrett have noted the beaded ridges on the posterior as a means of distinction.

Occurrence.—Although rather rare, *C.* (*H.*) *veatchi* occurs throughout the Sabine of Alabama. It has previously been reported from Sabinetown and Marthaville, La., and Pendleton, Tex.

Types.—Hypotypes, H. V. Howe coll., no. 1458 from Loc. 4; other specimens, nos. 1459, 1460, from Loc. 3.

CYTHERIDEA (HAPLOCYTHERIDEA) WALLACEI Howe and Garrett
Plate 67, figure 25; text figures 17, 18

Cytheridea wallacei HOWE and GARRETT, *1934*, Louisiana Dept. Cons., Geol. Bull. 4, pp. 44, 45, pl. 3, figs. 5–8.

Very rare specimens referred to this species occur in the Nanafalia and Hatchetigbee formations of Alabama. The Alabama material is identical with the original types from Louisiana except for minor variation in ornamentation. Louisiana specimens are finely and evenly papillose over the entire exterior, whereas those from Alabama show papillae only on the most inflated portion, the remainder of the surface to the periphery being smooth. The hinge of the right valve, according to Howe and Garrett, is composed of

two rather prominent taxodont dental areas about four times as long as wide, and with seven or more dentitions, connected by a low narrow crenulated bar, which is separated from the dorsal margin by a shallow trench, and in the left valve with two notched indented sockets, and a narrow, notched, indented, connecting area, above which is a straight narrow bar, which is separated from the dorsal margin by a shallow groove.

About 20 radial pore canals are present on the anterior. The line of concrescence coincides with the inner margin throughout. Muscle-scar pattern (text fig. 18) typical for the genus.

Length 0.80 mm; height 0.51 mm; width 0.45 mm.

Occurrence.—*C.* (*H.*) *wallacei* was originally described from the Nanafalia formation at Marthaville, La., and also reported to be present in the Bashi at Sabinetown, Tex. The species occurs rarely in the Nanafalia and Hatchetigbee formations of Alabama. The range of the species is therefore apparently throughout Sabine time, although I have no record of its occurrence in the Tuscahoma sand.

Types.—Hypotypes, H. V. Howe coll., no. 1429, from Loc. 3; other specimens, nos. 1430, 1431, from Loc. 9.

Subgenus CLITHROCYTHERIDEA Stephenson, 1936

CYTHERIDEA (CLITHROCYTHERIDEA) ALEXANDERI Stephenson, n. sp.
Plate 67, figures 19, 20; text figures 33, 34

Carapace rather large, heavy, tumid; in side view elongate, subtriangular,

highest at the anterior one-third of the shell length. Dorsal margin strongly arched over the high anterior cardinal angle, flattened along the hinge line, to the low, weak posterior cardinal angle. Ventral margin slightly concave, often partially obscured by the inflated side wall of the carapace. Anterior end broadly and obliquely rounded; posterior end gradually narrowed to the subacute postero-ventral angle. Tumid portion of surface covered with numerous subcircular depressions of moderate size showing no definite alignment; interspaces slightly raised to form an irregular reticulate pattern of ridges. Ornamentation becomes obscure near the periphery. Hinge in the right valve composed of two narrow, faintly notched, terminal dentitions, with a shallow connecting furrow. In the left valve, hinge with large, well-incised, deeply notched sockets, strongly overhung by lobes of the rounded bar connecting them, which is separated from the dorsal margin by an incised line. Marginal area quite broad, with the inner margin and line of concrescence appearing to coincide throughout. Muscle-scar pattern obscured.

Length (left valve) 0.78 mm; height 0.40 mm.

Named in honor of C. I. Alexander, for his excellent work on the Midway Ostracoda of Texas.

Occurrence.—This species is rather common but poorly preserved in the Midway at Matthews Landing. Figured specimens were obtained from Naheola Landing, where the species is rare.

Types.—Holotype (left valve), H. V. Howe coll., no. 1428; paratype, no. 1461.

CYTHERIDEA (CLITHROCYTHERIDEA) BROUSSARDI Howe and Garrett

Plate 67, figure 24; text figures 28, 29

Cytheridea? broussardi HOWE and GARRETT, *1934*, Louisiana Dept. Cons., Geol. Bull. 4, pp. 30, 31, pl. 1, figs. 12–15.

Carapace heavy, in side view subquadrate, highest anterior to the middle. Anterior end broadly and obliquely rounded; posterior end narrower, sloping steeply to the subacute postero-ventral angle. Dorsal margin nearly straight along the hinge line, sloping gently toward the posterior; ventral margin somewhat concave. Surface somewhat irregular, with a horizontally elongated depression usually visible ventral to the center of the carapace; surface pitting pronounced, leaving a slightly raised pattern of slender, irregular, reticulate ridges between pits. A heavy thickened rim of clear shell material extends around

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EXPLANATION OF TEXT FIGURES 1–18

All figures ×60

FIGS. *1, 2*—*Cytheridea* (*Haplocytheridea*) *leei* Howe and Garrett. *1*, Interior of left valve of a female. *2*, Hinge structure of right valve.

3, 4—*Cytheridea* (*Haplocytheridea*) *moodyi* Howe and Garrett. *3*, Interior of left valve. *4*, Hinge structure of right valve.

5, 9, 10, 16—*Cytheridea* (*Haplocytheridea*) *sabinensis* Howe and Garrett. *5*, Muscle scar pattern of left valve. *9*, Interior of left valve. *10*, Interior of right valve, showing hinge and pore canals. *16*, Dorsal view.

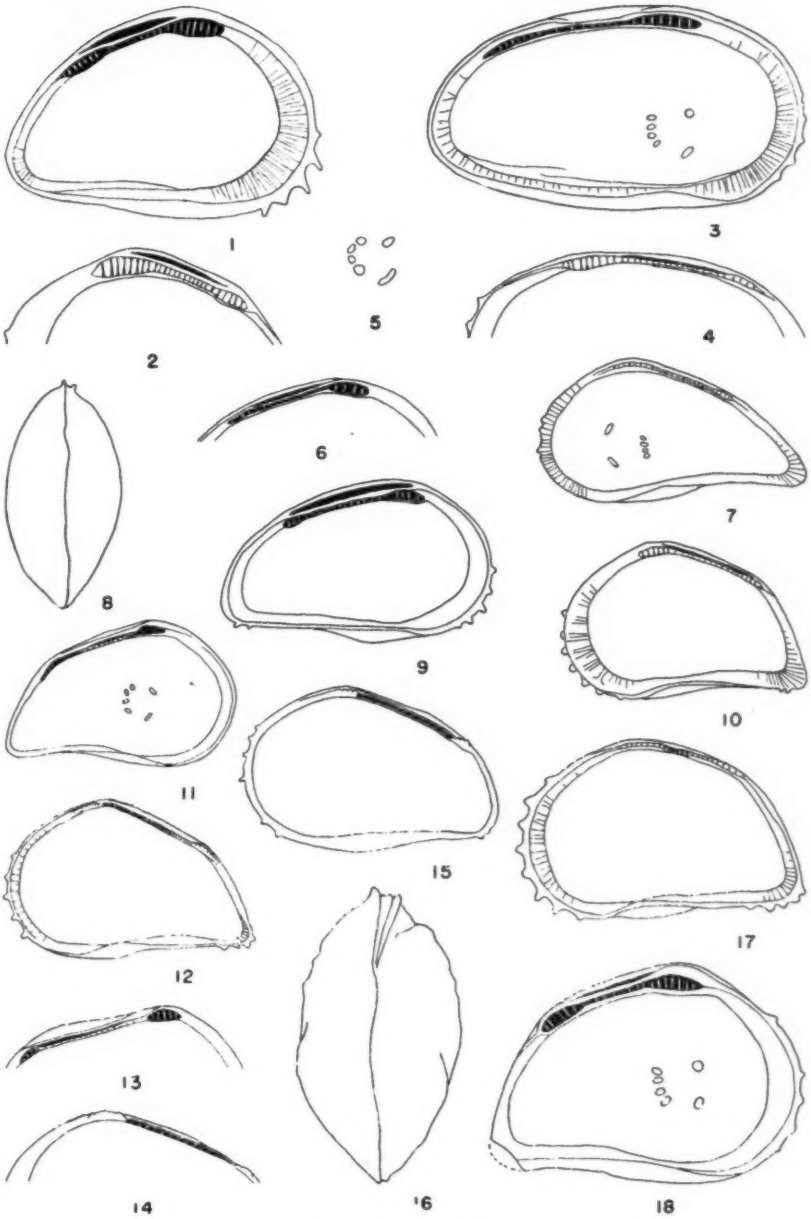
6, 7—*Cytheridea* (*Haplocytheridea*) *marthavillensis* Howe and Garrett. *6*, Hinge structure of left valve. *7*, Interior of right valve.

8, 11, 12—*Cytheridea* (*Leptocytheridea*) *hopkinsi* Howe and Garrett. *8*, Dorsal view. *11*, Interior of left valve, showing hinge and muscle scar pattern. *12*, Interior of right valve, showing hinge and radial pore canals.

13, 14—*Cytheridea* (*Leptocytheridea*) *naheolensis* Stephenson, n. sp. *13*, Hinge of left valve. *14*, Hinge of right valve.

15—*Cytheridea* (*Clithrocytheridea*) *tuscahomensis* Stephenson, n. sp. Interior of right valve, showing hinge structure.

17, 18—*Cytheridea* (*Haplocytheridea*) *wallacei* Howe and Garrett. *17*, Interior of right valve, showing hinge and pore canals. *18*, Interior of left valve, showing hinge and muscle-scar pattern.



TEXT FIGURES 1–18.

the anterior end, strongly developed in the right valve, but weak in the left. Hinge line strongly developed, as originally described consisting in the right valve of

two elongated taxodont dental areas with six to eight dentitions each and connected by a narrow, notched groove; in the left valve with two elongated, notched sockets, the anterior one being larger; sockets connected by a narrow, high, crenulated bar, above which is a furrow, and above this there is a faint bar which slopes off sharply to the dorsal margin.

Marginal areas fairly broad, carrying numerous straight, simple radial pore canals. Inner margin and line of concrescence coincide throughout. Muscle-scar pattern (text fig. 28) typical for the genus.

Length (left valve) 0.72 mm; height 0.42 mm.

Occurrence.—The species has previously been reported by Howe and Garrett from the upper three members of the Sabine. I have specimens from the Nanafalia (Loc. 4) as well, thus giving the species a range throughout the Sabine.

Types.—Hypotypes, H. V. Howe coll., nos. 1432, 1433, from Loc. 7.

CYTHERIDEA (CLITHROCYTHERIDEA) NANAFALIENSIS Stephenson, n. sp.
Plate 67, figures 9, 10; text figures 32, 35, 36

Carapace tumid; in side view elongate, subovate, highest at the anterior one-third of the shell length. Dorsal margin gently arched, flattened along the hinge line; ventral margin almost straight. Anterior end broadly rounded; posterior end narrower, obliquely truncated to the rounded postero-ventral angle in the left valve, sloping to the subacute postero-ventral angle in the right valve. Inflated portion of surface covered with numerous deep, subcircular to ovoid depressions, at times aligned in shallow furrows separated by slightly raised ridges. Hinge in the right valve consists of terminal taxodont dental areas divided into about six cusps, truncated into a depressed, crenulate, connecting trench, above which the dorsal margin extends as a low, rounded bar. In the left valve, hinge with strongly notched, well-incised sockets, with an elevated, crenulate connecting bar between them, separated from the dorsal margin by a faintly incised line. Marginal areas fairly broad, carrying about 30 straight, simple radial pore canals on the anterior, more closely spaced on the ventral half. Line of concrescence and inner margin coincide throughout. A carinate ventral ridge on the right valve fits into a grooved lip line on the left valve. Muscle-scar pattern obscure.

Length (complete specimen) 0.62 mm; height 0.33 mm; width 0.28 mm.

Occurrence.—This species is apparently confined to the lower Sabine in Alabama. Specimens are common in the Nanafalia samples, and it occurs rarely at Greggs Landing.

Types.—Syntypes, H. V. Howe coll., nos. 1467, 1468, from Loc. 6; syntype, no. 1466, from Loc. 3.

CYTHERIDEA (CLITHROCYTHERIDEA) PENDLETONENSIS Howe and Garrett
Plate 67, figure 18; text figures 37, 38

Cytheridea pendletonensis HOWE and GARRETT, *1934*, Louisiana Dept. Cons., Geol. Bull. 4, pp. 36, 37, pl. 2, figs. 7–10.

Carapace small, heavy; in side view subpyriform, highest at the anterior one-third of the shell length. Dorsal margin well arched, somewhat concave and sloping gently to the posterior along the hinge line; ventral margin broadly concave. Anterior end broadly and obliquely rounded; posterior end compressed, sloping to the acute postero-ventral angle, which is somewhat produced ventrally. General surface rugged, strongly pitted, with two marked, longitudinal ridges converging anteriorly and posteriorly, leaving a central depressed area. Alabama specimens are much more highly ornamented than those from Louisiana and Texas. The holotype, from Pendleton, Tex., shows the dorsal ridge ter-

minated on the anterior by a pronounced node, which is smooth except for minute punctations, while in the Alabama material this node is very rugged and carved by numerous irregular depressions. The original description of the hinge was taken from poorly preserved specimens from Pendleton, and is inaccurate; it is here figured and redescribed from Alabama. Hinge in the right valve consists of two taxodont dental areas, notched to form about six cusps, abruptly truncated into a depressed, crenulate, connecting groove, above which a low bar slopes off dorsally and extends around the anterior dentition. In the left valve, hinge with notched, indented sockets, joined by a faintly crenulate bar, which is highest anteriorly, and which ends abruptly at the sockets. Above the bar and isolated from the sockets is a groove, strongly indented posteriorly. This groove separates the bar from the low dorsal margin. Marginal areas fairly broad, with the inner margin coinciding with the line of concrescence except on the anterior, where it is slightly inside it. Radial pore canals few in number, about 15 on the anterior. Muscle-scar pattern obscure.

Length (complete specimen) 0.45 mm; height 0.27 mm; width 0.24 mm.

Remarks.—The original description appears with this species named "*Cytheridea pendletonesis*," but in all other references to the species by Howe and Garrett the spelling is "*Cytheridea pendletonensis*." It is assumed that the latter spelling is the correct one, and I have adhered to it in the present work.

It is unlikely that *C.* (*C.*) *pendletonensis* will be confused with other species of the genus *Cytheridea* occurring in Gulf Coast sediments. It is much smaller than most other Tertiary species, and very heavy for its size. It is readily separated from *C.* (*L.*) *ruida* Alexander by its heavier, more rugged, strongly sculptured carapace, broader marginal areas, and heavier hinge structure.

Occurrence.—This species is very rare throughout the Sabine of Alabama.

Types.—Hypotypes, H. V. Howe coll., no. 1469, from Loc. 4; nos. 1470, 1471, from Loc. 8.

CYTHERIDEA (CLITHROCYTHERIDEA) TOMBIGBEENSIS Stephenson, n. sp.
Plate 67, figures 1, 2;
text figures 30, 31

Carapace heavy, tumid; in side view subpyriform, highest just anterior to the middle. Dorsal margin strongly arched, flattened along the hinge line; ventral margin straight or slightly convex. Anterior end broadly rounded in the left valve, more narrowly and obliquely rounded in the right valve. Posterior end narrower, steeply sloping to the rounded postero-ventral angle. Entire surface very finely and evenly punctate, with numerous shallow pits of moderate size marking the position of normal pore canals. Hinge in the right valve composed of two elongate, notched dental areas at the cardinal angles, gently sloping to join a well-intrenched, finely crenulate furrow connecting them. The groove is enclosed dorsally by the low, broadly rounded dorsal margin. In the left valve, hinge with strongly depressed, deeply incised terminal sockets, notched to form about six segments, and overhung by lobes of the dorsal margin. A narrow, high, overhanging, crenulate bar connects the sockets, set off from the faintly visible dorsal margin by a broad, weakly depressed area. Marginal areas moderately broad, with the inner margin coinciding with the line of concrescence throughout. Radial pore canals simple, unbranched, about 40 in number on the anterior. A ventral carinate ridge on the right valve fits into a grooved lip line on the ventral margin of the left valve. Muscle-scar pattern (text fig. 31) typical for the genus.

Length (left valve) 0.75 mm; height 0.47 mm.

Remarks.—This species bears considerable resemblance to *C.* (*C.*) *grigsbyi* Howe and Chambers (1935), from the Jackson Eocene. The Jackson species is widely variable in shape in side view, and cannot be separated on this feature. The pits

marking the position of normal pore canals on *C.* (*C.*) *tombigbeensis* are, however, entirely lacking or only very faintly visible on *C.* (*C.*) *grigsbyi*, which usually exhibits only a fine, granular pitting of the carapace.

Occurrence.—This species occurs commonly at Hatchetigbee Bluff on the Tombigbee River, as well as at Yellow Bluff.

Types.—Syntypes, H. V. Howe coll., nos. 1434, 1435, from Loc. 9.

CYTHERIDEA (CLITHROCYTHERIDEA) TUSCAHOMENSIS Stephenson, n. sp.
Plate 67, figures 15, 16; text figure 15

Carapace tumid, fairly heavy; in side view subpyriform, highest anteriorly, longest and thickest toward the ventral side. Dorsal margin well arched, fairly straight along the hinge line, sloping to the posterior; ventral margin convex, somewhat contracted in the posterior one-third of its length. Anterior end broadly and evenly rounded, bearing about six short, fine spines on the right valve. Posterior end somewhat compressed, steeply truncated to the narrowly rounded postero-ventral angle, which is slightly produced ventrally. Peripheral areas of the surface smooth, rising steeply on the ventral side to the inflated portion, which slopes off gently to the dorsal side, and is covered with strong, closely spaced pits. A slight node is visible near the ventral margin at the posterior one-third of the shell length, in front of which several low ridges near and parallel to the ventral margin extend around the anterior end. Hinge in the right valve composed of two raised, slightly notched dental areas, connected by a crenulate incision, which is deepest immediately behind the anterior dentition. In the left valve, hinge with indented sockets, between which a slight bar extends, which is high on the anterior, and gradually becomes lower toward the posterior socket.

Length (right valve) 0.61 mm; height 0.39 mm.

Occurrence.—The two figured specimens, both from the Tuscahoma formation at Bells Landing, are the only representatives of the species known to me. The description is based mainly on the right valve, as the left is small, and apparently immature.

Types.—Holotype, H. V. Howe coll., no. 1462; paratype, no. 1463.

EXPLANATION OF TEXT FIGURES 19–38

All figures ×60

FIGS. *19, 20—Cytheridea* (*Leptocytheridea*) *bashiensis* Stephenson, n. sp. *19*, Interior of right valve, showing hinge and pore canals. *20*, Interior of left valve, showing hinge structure.

21, 22—Cytheridea (*Leptocytheridea*) *alabamensis* Stephenson, n. sp. *21*, Interior of left valve. *22*, Hinge structure of right valve.

23, 24—Cytheridea (*Haplocytheridea*) *harrisi* Stephenson, n. sp. *23*, Interior of left valve. *24*, Interior of right valve.

25–27—Cytheridea (*Haplocytheridea*) *veatchi* Howe and Garrett. *25*, Dorsal view. *26*, Interior of left valve. *27*, Hinge structure of right valve.

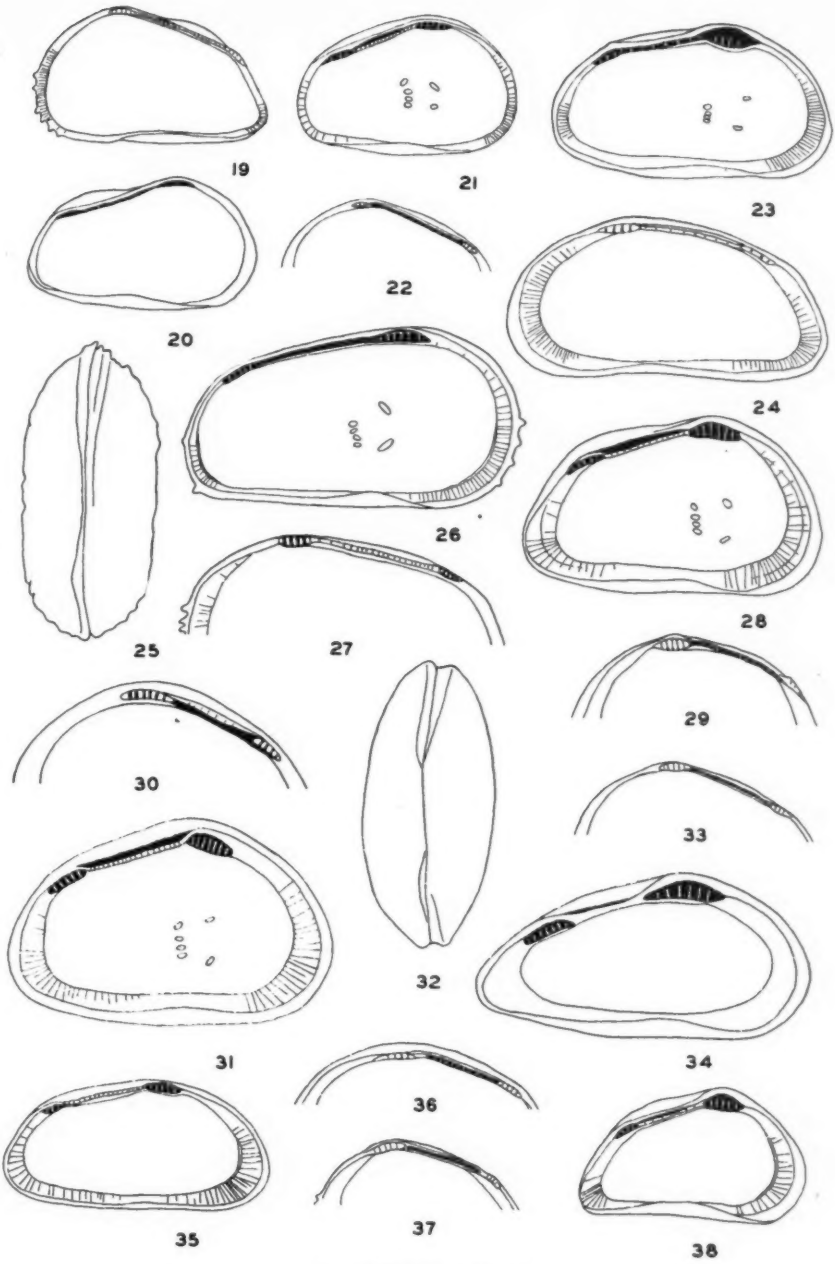
28, 29—Cytheridea (*Clithrocytheridea*) *broussardi* Howe and Garrett. *28*, Interior of left valve. *29*, Hinge structure of right valve.

30, 31—Cytheridea (*Clithrocytheridea*) *tombigbeensis* Stephenson, n. sp. *30*, Hinge structure of right valve. *31*, Interior of left valve.

32, 35, 36—Cytheridea (*Clithrocytheridea*) *nanafaliensis* Stephenson, n. sp. *32*, Dorsal view. *35*, Interior of left valve. *36*, Hinge of right valve.

33, 34—Cytheridea (*Clithrocytheridea*) *alexanderi* Stephenson, n. sp. *33*, Hinge of right valve. *34*, Interior of left valve.

37, 38—Cytheridea (*Clithrocytheridea*) *pendletonensis* Howe and Garrett. *37*, Hinge structure of right valve. *38*, Interior of left valve.



TEXT FIGURES 19–38

Subgenus LEPTOCYTHERIDEA
Stephenson, 1937

CYTHERIDEA (LEPTOCYTHERIDEA)
ALABAMENSIS Stephenson, n. sp.

Plate 67, figures 7, 8;
text figures 21, 22

Carapace small, fragile, tumid; in side view subpyriform, greatest height anterior to the middle, greatest inflation posterior to the middle. Dorsal margin strongly arched, almost straight along the hinge line; ventral margin slightly convex. Anterior end high, broadly rounded; posterior end much narrower, but well rounded. Entire surface finely and evenly punctate, smooth except for a few very slightly raised, narrow ridges subparallel to the periphery, scarcely noticeable on many specimens. Hinge in the right valve composed of two very narrow, elongate dental areas divided into three or four cusps, between which is a narrow, finely crenulated groove, above which the dorsal margin is slightly raised. In the left valve, hinge with corresponding notched sockets, connected by a slender bar, which is most prominent on the anterior, and which is separated from the low dorsal margin by a shallow, fairly broad depressed area. An overhanging ventral flange on the interior of the left valve fits over a smaller flange on the right valve. Marginal zone very narrow, with the inner margin coinciding with the line of concrescence throughout. Radial pore canals short, straight, simple, about 25 in number on the anterior. Muscle scars are six in number, four of which are in a vertical row in the middle of the carapace, the upper scar slightly removed from the other three, with two oblique, elongate scars anterior to them.

Length (left valve) 0.52 mm; height 0.33 mm.

Occurrence.—This diminutive species appears to be confined to the upper Sabine in Alabama. It occurs in my collections from the Bashi and Hatchetigbee formations, at Locs. 7, 8, and 9.

Types.—Syntypes, H. V. Howe coll., nos. 1436, 1437, from Loc. 7.

CYTHERIDEA (LEPTOCYTHERIDEA)
BASHIENSIS Stephenson, n. sp.

Plate 67, figure 17;
text figures 19, 20

Carapace small, fragile, tumid; in side view subpyriform, highest near the anterior end. Dorsal margin straight and sloping gently toward the posterior, obscured in side view toward the posterior by the inflated side wall of the carapace; cardinal angles well rounded. Ventral margin nearly straight. Anterior end broadly rounded; posterior end obliquely truncated to the somewhat rounded postero-ventral angle. Tumid portions of the carapace covered with rather small, shallow pits. Surface somewhat irregular, with two fairly well defined nodes, one slightly ventral to the middle at the anterior one-third of the length of the carapace, the other more prominent and somewhat dorsal to it at about one-third the shell length from the posterior. A rounded ridge near and parallel to the ventral margin extends from a point just below the anterior node toward the posterior, becoming obscure before reaching the postero-ventral angle. Hinge in the right valve with slender, elongate, faintly notched dental areas, the posterior higher and more pronounced. The terminal teeth slope gently into the slender, depressed line of the hinge between them, which is very faintly grooved and slightly crenulate. In the left valve, hinge composed of slender, obscure, notched sockets corresponding to the teeth in the right valve, with a narrow, faintly notched bar between and truncated into them. Marginal areas very narrow, with the line of concrescence coinciding with the inner margin throughout. Radial pore canals numerous, straight, unbranched. Muscle-scar pattern obscured.

Length (left valve) 0.53 mm; height 0.30 mm.

Occurrence.—*C.* (*L.*) *bashiensis* is a rather rare species, probably occurring throughout the Sabine section of Alabama. It occurs in my collections from

all horizons except the Tuscahoma. Figured specimens are from Loc. 7.

Types.—Holotype, H. V. Howe coll., no. 1446; other specimen, paratype no. 1455.

CYTHERIDEA (LEPTOCYTHERIDEA) HOPKINSI Howe and Garrett
Plate 67, figures 13, 14; text figures 8, 11, 12

Cytheridea hopkinsi HOWE and GARRETT, *1934*, Louisiana Dept. Cons., Geol. Bull. 4, pp. 31, 32, pl. 1, figs. 16–18.

Carapace small, fragile, tumid; in side view elongate, subpyriform, highest at the anterior one-third the shell length. Dorsal margin gently arched, flattened along the hinge line, and sloping toward the posterior; ventral margin broadly sinuated, convex on the anterior and concave on the posterior. Anterior end well rounded, faintly spinose on the ventral half; posterior end acute, compressed, produced ventrally, with the postero-ventral angle very faintly spinose in some specimens. Surface smooth except for numerous closely spaced, very fine pits on the most inflated portion. Hinge in the right valve consists of terminal dental areas, each notched to form five to six cusps. Immediately behind the anterior dentition is a pronounced crenulate groove, deepest on its anterior end, and becoming obscure at about the midpoint of the hinge line, where it is replaced by a low line of crenulations which becomes more prominent as it approaches and finally merges with the posterior dentition. In the left valve, hinge with notched terminal sockets corresponding to the dental areas in the right valve. A slender bar between the sockets is highest on its anterior end, becoming less prominent as it slopes into a groove which joins the posterior socket. A faintly depressed area separates the bar from the dorsal margin. Marginal areas very narrow, with the inner margin coinciding with the line of concrescence throughout. Radial pore canals fairly numerous on the anterior, fewer on the posterior. Six muscle scars are present, four of which are in a vertical row slightly concave toward two scars anterior to them.

Length (complete specimen, male) 0.52 mm; height 0.32 mm; width 0.29 mm.

Remarks.—Sexual dimorphism is marked in this species, with the female (pl. 67, fig. 14) higher and more rounded in outline than the male (pl. 67, fig. 13). The posterior end of the female is likewise more steeply sloping, with a less acute postero-ventral angle, which is not produced below the general line of the ventral margin.

C. (*L.*) *hopkinsi* is quite similar to *C.* (*L.*) *kellumi* Howe and Stephenson (1935), from the Jackson Eocene of Louisiana. The Jackson species has, however, a much less acute postero-ventral angle, which is not produced ventrally, and is somewhat more inflated on the posterior.

Occurrence.—This species, originally described from the Nanafalia of Louisiana, is common at Locs. 3, 4, and 6. The species therefore appears to occur in the Nanafalia and Tuscahoma formations of the lower Sabine of Alabama.

Types.—Hypotypes, H. V. Howe coll., nos. 1438–1441, from Loc. 3.

CYTHERIDEA (LEPTOCYTHERIDEA) NAHEOLENSIS Stephenson, n. sp.
Plate 67, figure 21; text figures 13, 14

Carapace thin, fragile; in side view elongate, subpyriform, highest at the anterior one-third the shell length. Dorsal margin moderately well arched, flattened along the hinge line; ventral margin almost straight, slightly concave. Anterior end broadly and obliquely rounded; posterior end narrow, steeply truncated to the subacute postero-ventral angle. Surface rather strongly sculptured. A well elevated node near the dorsal margin at the posterior one-third the shell length is connected with a low ridge, which extends toward the posterior, where it becomes obscure. A second ridge, below the first and subparallel to the ventral margin, is fairly prominent in the pos-

terior half of the carapace, becoming obscure near the midpoint, and merges with a slightly thickened area of the shell wall in the center of the carapace. A somewhat thickened rim just inside the anterior margin and parallel to it is most prominent in its dorsal half. Entire surface rather closely covered with fairly strong pits, which often carve into the ridges. Hinge line very delicate, consisting in the right valve of narrow, slightly raised, very faintly notched dental areas, between which is a faintly visible groove, outlined dorsally by the narrow dorsal margin. In the left valve, hinge with narrow, faintly incised sockets, between which is a slender bar which is separated from the dorsal margin by a shallow depressed area. Marginal areas so narrow that they are little more than the thickness of the shell. Radial pore canals and muscle-scar pattern not visible.

Length (left valve) 0.45 mm; height 0.25 mm.

Remarks.—This species bears considerable resemblance to the form described by Alexander (1934, p. 224, pl. 33, fig. 7) as *Cytheridea ruida* from the basal clays and glauconitic clays of the Kincaid (Midway) formation of Texas. The new species has a thinner, more fragile carapace, and shows less sculpturing. The ridge just inside the anterior margin, which is pronounced in *C. ruida*, is only slightly raised in the new species. The Texas form likewise shows much broader anterior and posterior marginal zones, and the hinge line is much stronger.

Occurrence.—*C.* (*L.*) *naheolensis* has been observed by me at a single station, Matthews Landing, in Alabama, where it occurs in the Naheola formation of the Midway.

Types.—Syntypes, H. V. Howe coll., nos. 1464, 1465, from Loc. 1.

LOCALITIES

(The location of outcrops of these formations is taken from *Alabama Geol. Survey, Special Rept.* 14, 1926.)

Loc. 1.—An exposure of Naheola Midway on Alabama River at Matthews Landing, in the northern part of sec. 12, T. 12 N., R. 6 E., Wilcox County, Ala. Collected by H. V. Howe.

Loc. 2.—The type locality of the Naheola formation, at Naheola Landing on the west bank of Tombigbee River, secs. 30 or 31, T. 15 N., R. 1 E., Choctaw County, Ala. Collected by Karl E. Young.

Loc. 3.—The type locality of the Nanafalia formation, lowest faunal unit of the Sabine of Alabama, at Nanafalia Landing on Tombigbee River, sec. 31, T. 14 N., R. 1 E., Marengo County, Ala. The material examined is from bed 2 (*Ostrea thirsae* zone) of the section of the landing given in Alabama Special Report 14, page 259. Collected by Karl E. Young.

Loc. 4.—Same horizon as Loc. 3, 17 miles north of Thomasville and 5 miles north of Dixons Mill on the Thomasville-Linden highway, Marengo County, Ala. Collected by B. W. Blanpied.

Loc. 5.—An exposure of the Tuscahoma formation at Bells Landing on Alabama River, sec. 36, T. 10 N., R. 6 E., Monroe County, Ala. Collected by H. V. Howe.

Loc. 6.—Tuscahoma formation exposed at Greggs Landing on Alabama River, about 4 miles southeast of the old town of Lower Peachtree, Monroe County, Ala. This material is from bed 2 of the section of the bluff given in Alabama Special Report 14, pages 263, 264. Collected by Karl E. Young.

Loc. 7.—An outcrop of the Bashi formation at Yellow Bluff, on the west side of Alabama River, near the corner of secs. 13 and 24, T. 11 N., R. 5 E., Wilcox County, Ala. The material studied is from bed 6 of the section of the bluff given in Alabama Special Report 14, page 265. Collected by Karl E. Young.

Loc. 8.—An exposure of the Bashi formation at Woods Bluff on Tombigbee River, 8 miles by water below Bashi Creek, Clarke County, Ala. Collected by H. V. Howe.

Loc. 9.—The Hatchetigbee formation, uppermost horizon of the Sabine of Alabama, as exposed at the type locality, Hatchetigbee Bluff on Tombigbee River, Washington County, Ala., 3 miles south of the Choctaw County line. Collected by H. V. Howe.

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CLAIBORNE EOCENE SPECIES OF THE OSTRACODE GENUS LOXOCONCHA

GROVER MURRAY, JR.

ABSTRACT

Eight new species and one new variety of *Loxoconcha* are described. Relative specific values, stratigraphic ranges, and minor generic divergences are discussed. Specific descriptions, check list, and bibliography complete the paper.

The ostracode genus *Loxoconcha* was first described by G. O. Sars (1865, 1926) C. I. Alexander (1934) redescribed the genus, placing emphasis on the carapace structure.

Eight new species (*L. lisbonensis*, *L. claibornensis*, *L. chamfera*, *L. edwardsi*, *L. unispinosa*, *L. mcbeanensis*, *L. howei*, and *L. surreala*) and one new variety (*L. chamfera* var. *diverta*) have been determined. Affinities to previously described species are noticeable in some forms, but I feel that the observed differences are sufficient to warrant differentiation of the new species described here. Three other possible species are not described because of insufficient specimens or because of poor preservation of carapaces.

A survey of available literature brings out the fact that no previously described species of *Loxoconcha* occur in sediments of Claiborne age, nor have I found any of the Claiborne species in materials of other age. Howe and Chambers (1935) have described four species of *Loxoconcha* from the Jackson Eocene, Howe and Law (1936) one species from the Vicksburg Oligocene, Alexander (1934, 1936) four species from the Midway Eocene and two species from the Cretaceous, and Israelsky (1929, 1935) one species from the Cretaceous. Each of the described species, including those of the present paper, apparently has a narrow stratigraphic range. These apparently limited stratigraphic ranges may be due, however, either to faulty observation or to lack of detailed work involving the complete section from Cretaceous to Oligocene. Assuming that the work has not been faulty in any respect, the described species of *Loxoconcha*, despite their small size, fragility, and relative rarity, should prove useful in correlation and zonation. The described species are distributed as follows:

DESCRIBED SPECIES OF LOXOCHONCHA

Tertiary system, Eocene series
- Vicksburg group
  - *Loxochoncha woodwardensis* Howe and Law, 1936
- Jackson group
  - *Loxochoncha buntoni* Howe and Chambers, 1935
  - *Loxoconcha creolensis* Howe and Chambers, 1935
  - *Loxoconcha jacksonensis* Howe and Chambers, 1935
  - *Loxoconcha mornhinvegi* Howe and Chambers, 1935
  - *Loxoconcha vernonensis* Howe and Chambers, 1935
- Claiborne group
  - *Loxoconcha lisbonensis* Murray, 1938
  - *Loxoconcha claibornensis* Murray, 1938
  - *Loxoconcha chamfera* Murray, 1938
  - *Loxoconcha chamfera* var. *diverta* Murray, 1938
  - *Loxoconcha edwardsi* Murray, 1938
  - *Loxoconcha mcbeanensis* Murray, 1938
  - *Loxoconcha howei* Murray, 1938
  - *Loxoconcha surreala* Murray, 1938
  - *Loxoconcha unispinosa* Murray, 1938
- Midway group
  - *Loxoconcha perdecora* Alexander, 1934
  - *Loxoconcha nuda* Alexander, 1934
  - *Loxoconcha corrugata* Alexander, 1934
  - *Loxoconcha prava* Alexander, 1934

Cretaceous system
- *Loxoconcha fletcheri* Israelsky, 1929, 1935
- *Loxoconcha cretacea* Alexander, 1936
- *Loxoconcha brownstownensis* Alexander, 1936

The present study of Claiborne species of *Loxoconcha* supports the correctness

of Alexander's generic description. There are, however, a few points worthy of discussion. An anterior tubercle over the anterior end of the hinge line is usually not present in Claiborne forms. In addition, these forms usually exhibit a tendency toward loss of the keel on the postero-ventral edge of the valves.

The hinge in Claiborne species consists of more or less open, horseshoe-shaped, anterior and posterior teeth in each valve, apparently interlocking when the valves are closed. In the right valve the anterior tooth is open dorsally, the posterior tooth open ventrally. In the left valve the anterior tooth is open ventrally, the posterior tooth, if horseshoe-shaped, is open dorsally. The anterior sockets of each valve are somewhat pyriform, the posterior sockets ovate, elongate, or horseshoe-shaped. The bar of the left valve in the majority of Claiborne species is distinctly notched. In several forms there is a distinct tendency toward development of both groove and bar in the left valve with a corresponding bar and groove in the right valve. The posterior teeth and sockets are more strongly developed than are the anterior ones.

The muscle-scar pattern, as in Cretaceous and other Tertiary forms, is obscured by surface sculpture. The external ornamentation is reflected to some extent within the valves, the amount of reflection varying from species to species.

Types.—Holotypes, syntypes, and topotypes are deposited in the Henry V. Howe Collection, School of Geology, Louisiana State University.

Acknowledgments.—Thanks are due Dr. H. V. Howe, John Huner, Keith Hussey, Justin Rukas, and David Gooch for suggestions and loan of materials.

SYSTEMATIC DESCRIPTIONS

Order OSTRACODA Latreille

Suborder PODOCOPA Sars

Family CYTHERIDAE Baird, 1850

Genus LOXOCONCHA Sars, 1865

Genotype *Loxoconcha impressa* (Baird). *Loxoconcha rhomboidea* Sars, 1865-*Cythere impressa* Baird, 1850, Natural History of British Entomostraca, p. 175, pl. 21, fig. 9.

LOXOCONCHA LISBONENSIS Murray, n. sp.

Plate 68, figures 1, 13

Carapace small, in dorsal view somewhat lens-shaped, compressed slightly toward anterior end, subovate when viewed laterally, thickest posterior to the middle. Dorsal margin straight, sloping abruptly to a very blunt posterior caudal spine. Posterior end subangular. Postero-ventral margin subrounded, postero-ventral angle larger than postero-dorsal angle. Ventral margin convex. Anterior end obliquely rounded, greatest obliquity toward ventral side, gentle slope from dorsal margin. Surface ornamentation consists of subangular to rounded pits arranged in a reticulate pattern anteriorly, elsewhere tending to occur in rows separated by sharp, somewhat serrate ribs trending roughly from antero-ventral to postero-dorsal angle. Near postero-ventral angle three to five of the more prominent ribs bend upward and toward the postero-dorsal angle. In dorsal view pits appear to be arranged in reticulate pattern. In ventral view, species characterized by anterior convergence of about three distinct ribs. Ribs reflected in posterior outline as projections on general convexity of carapace. Hinge typical of genus. At least three radial pore canals posteriorly, at least seven anteriorly.

Dimensions of a complete carapace, syntype slide no. 2000: length, 0.38 mm; height, 0.24 mm; thickness, 0.20 mm.

Remarks.—This species differs from *L. claibornensis* in having deeper pits, in sharper divides between pits, and in ventral detail. Well-preserved specimens are easily distinguished from *L. claibornensis*. Brady, Crosskey and Robert-

son (1874) figure a specimen of *L. guttata* Norman, which is likewise similar to *L. lisbonensis* but possesses a different shape, a different arrangement of reticulations, and also fewer reticulations.

Occurrence.—Type locality, Lisbon formation, Coffeeville, Ala., H. V. Howe, collector.

LOXOCONCHA CLAIBORNENSIS Murray, n. sp.
Plate 68, figures 2, 19

Carapace in side view ovate elongate, males distinctly longer than females. Dorsal margin straight, ventral margin straight to convex with sometimes a slight indentation near the transverse median line. Anterior end obliquely rounded, greatest obliquity ventral to longitudinal median line. Posterior end subangular to rounded, with blunt caudal spine. Slight indentation sometimes present just posterior to the longitudinal median line. Lens-shaped in dorsal view swelling just posterior to the middle. Carapace bulges ventrally so that greatest thickness is just posterior and ventral to middle of carapace. Surface ornamentation consists of rounded to subangular pits arranged, near edges of carapace, in rows more or less parallel to margins of carapace. Centrally there is a lack of arrangement in rows, and the pattern seems somewhat reticulate. A branching rib is usually present near center of carapace, the branches being open posteriorly. The interior of valves shows broad marginal areas, widest near postero-ventral angle. Ventral flange in each valve. Strong lip line present in right valve from posterior end to near antero-ventral angle. Anteriorly, radial pore canals 8 to 10 in number, posteriorly, 4 to 6 in number. Line of concrescence slightly indented at radial pore canals. Inner margin projects slightly. Hinge in right valve consists of an anterior horseshoe-shaped tooth, open dorsally, ventral to and partially enclosing a shallow socket. The tooth bulges anteriorly and posteriorly. A small oblong tooth is usually present dorsal to the socket. A small bar, more or less connected to the anterior tooth, extends backward to a posterior horseshoe-shaped tooth, open ventrally, dorsal to a shallow socket. The posterior tooth bulges slightly anteriorly, very much so posteriorly. A fine, slightly crenulate groove extends down the center of the bar.

Dimensions of a complete carapace, syntype slide no. 2002: length, male, 0.42 mm, female, 0.36 mm; height, male, 0.23 mm, female, 0.24 mm.

Remarks.—This form exhibits numerous variations in structure and represents perhaps more than one species. Due to the difficulty involved in separating these forms, however, it is believed best to include them under a single species. It differs from *L. woodwardensis* Howe and Law (1936), from the Vicksburg of Louisiana, in outline, in the more elongate form, and in the presence of ridges and of rows of pits on ventral side of carapace. Similarly, it departs from *L. perdecora* Alexander (1934), from the Midway of Texas, in the presence of ribs and pits arranged in rows on the ventral portion of carapace.

Occurrence.—Type locality, Lisbon formation, E. A. Smith's bed 14 (Smith, Johnson, Langden, 1894), Claiborne Bluff, Ala.; H. V. Howe, collector.

LOXOCONCHA CHAMFERA Murray, n. sp.
Plate 68, figures 3, 18

Carapace in side view elongate ovate. Dorsal margin straight; ventral margin short, straight to slightly convex. Anterior end broadly rounded, slightly oblique. Lens-shaped in dorsal view, greatest bulge just anterior to the middle. Posterior end subangular, sloping gently from the ventral margin and abruptly from the dorsal margin, concave between postero-dorsal angle and posterior extremity; postero-ventral margin almost straight. External ornamentation consists of prominent rounded ribs converging toward anterior and posterior ends. Troughs between ribs consist almost en-

tirely of more or less evenly spaced rounded pits. In interior view, both valves are flanged ventrally. In right valve, prominent lip line extends from posterior extremity along ventral marginal area to antero-ventral angle. Inner margin projects slightly. Anterior radial pore canals six or more in number, difficult to see. Posterior radial pore canals four or more in number, one usually bifurcating. Line of concrescence slightly indented at pore canals. Hinge consists of more or less interlocking horseshoe-shaped teeth connected by a bar. In right valve hinge consists of an anterior tooth, open dorsally, ventral to and partially enclosing a socket. Posterior knob of tooth larger than anterior knob. A small circular tooth is usually dorsal to the socket. Entire marginal area between anterior and posterior teeth forms a bar, in the center of which is a finely crenulate groove. Posteriorly there is a horseshoe-shaped tooth, open ventrally, dorsal to a socket and tending to be elongated into a very small bar extending toward the posterior extremity.

Dimensions of an entire specimen, syntype slide no. 2003: length, 0.38 mm, height, 0.24 mm, thickness, 0.20 mm.

Typical specimens of the species exhibit a surprising regularity in surface ornamentation and detail.

Remarks.—Worn specimens of *L. claibornensis* resemble this species to a certain extent, differing from it, however, in shape and in absence of ribs on the central and dorsal portions of the carapace. *L. chamfera* is likewise similar to *L. corrugata* Alexander (1934), from the Midway of Texas, and *L. cretacea* Alexander, from the Cretaceous of Texas. It departs, however, from *L. corrugata* in the presence of ribs on the central portion of the carapace and in shape. *L. cretacea* possesses ribs over the entire carapace but the pits between the ribs are semirectangular in shape while those of *L. chamfera* are more or less circular.

Occurrence.—Type locality, Cook Mountain formation, ditch leading to creek on south side of lower Dodson road, Winn Parish, La., NE ¼ SW ¼ sec. 28, T. 13 N., R. 3 W.; upper 2 feet of 12 foot bed; John Huner, collector.

LOXOCONCHA UNISPINOSA
Murray, n. sp.
Plate 68, figures 4, 14, 17

Carapace elongate, inflated, fragile. Dorsal margin straight; ventral margin overlapped by inflated portion of carapace. Anterior end rounded, somewhat obliquely, bordered by a thin flange or rib. Posterior end subangular, with caudal spine. Postero-ventral angle greater than antero-ventral angle. Surface ornamentation consists of deep subangular pits arranged in reticulate pattern over most of carapace but tending toward arrangement in rows near ventral edge. Pits separated by thin flat-topped ridges. Seven to ten ridges extend to margin of carapace on anterior end and two to four to margin on posterior end. A single moderately long spine arises ventral and posterior to middle of carapace; it is flanged slightly on anterior and posterior sides, and the spine is inclined slightly toward posterior end. From the highest portion, just ventral to middle, the carapace slopes gradually to dorsal, anterior, and posterior margins and abruptly to ventral margin. Viewed interiorly, both valves possess broad marginal areas, flanged ventrally. Inner margin projects slightly. Right valve possesses prominent lip line extending from about posterior extremity along ventral marginal area to antero-ventral angle. Line of concrescence distinctly indented at radial pore canals. Radial pore canals 8 to 12 in number anteriorly, 5 to 9 in number posteriorly. Hinge consists, in right valve, of an anterior, horseshoe-shaped tooth bulging at the extremities, ventral to and partially enclosing a somewhat ovate socket. Extending from the socket backward to a posterior tooth is a fairly crenulate groove bordered dorsally and ventrally by small bars. The posterior tooth is horseshoe-shaped, open ventrally, and partially enclosing a small, roughly circular socket.

Dimensions of complete specimen, syntype slide no. 2007: length, 0.40 mm; height, 0.26 mm.

Remarks.—This is one of the most distinctive species of *Loxoconcha* observed in Claiborne materials. However, its fragility and relative rarity detract from its usefulness as a guide fossil.

Occurrence.—Type locality, Cook Mountain formation, a ditch leading to creek on south side of lower Dodson road, Winn Parish, La., NE ¼ SW ¼ sec. 28, T. 13 N., R. 3 W.; upper 2 feet of 12 foot bed; John Huner, collector.

Loxoconcha surreala

Murray, n. sp.

Plate 68, figures 5, 8

Outline of carapace in side view a semiparallelogram. Dorsal margin straight; ventral margin slightly convex, somewhat overlapped by surface rib. Anterior end obliquely rounded. Posterior end subangular, sloping gradually from ventral margin, abruptly from dorsal margin, to a blunt caudal spine. Slight indentation between postero-dorsal and posterior extremity of caudal spine. Surface ornamentation consists of a prominent ventral rib bifurcating three or more times, and of ribs and tubercles haphazardly arranged on remainder of carapace. An interior view shows a fairly broad marginal area, ventrally flanged, with slightly projecting inner margin. In right valve a prominent lip line extends from near posterior caudal spine along ventral marginal area to antero-ventral angle. Radial pore canals few in number. Hinge consists in left valve of almost straight anterior tooth swollen at the extremities and more or less connected to a small bar, which extends backward to a posterior rounded tooth partially surrounded by a somewhat tear-shaped socket. Ventral and posterior to the socket is a small rounded tooth.

Dimensions of a left valve, syntype slide no. 2012: length, 0.33 mm; height, 0.20 mm.

Remarks.—This is the most distinctive species observed in Claiborne materials. Its fragility and rarity, however, detract from its usefulness as a guide fossil.

Occurrence.—Type locality, Cook Mountain formation, in a ditch leading to creek on south side of lower Dodson road, Winn Parish, La., NE ¼ SW ¼ sec. 28, T. 13 N., R. 3 W.; upper 2 feet of 12 foot bed; John Huner, collector.

Explanation of Plate 68

Figs. *1, 13*—*Loxoconcha lisbonensis* Murray, n. sp., ×70. *1*, Syntype slide no. 2000, exterior view of left valve. *13*, Syntype slide no. 2000, ventral view of entire carapace. (p. 587)

2, 19—*Loxoconcha claibornensis* Murray, n. sp., ×75. *2*, Syntype slide no. 2002, exterior view of left valve. *19*, Syntype slide no. 2002, interior view of right valve. (p. 588)

3, 18—*Loxoconcha chamfera* Murray, n. sp., ×75. *3*, Syntype slide no. 2003, exterior view of right valve. *18*, Interior view of right valve. (p. 588)

4, 14, 17—*Loxoconcha unispinosa* Murray, n. sp., ×75. *4*, Syntype slide no. 2007, exterior view of right valve. *14*, Syntype slide no. 2007, interior view of left valve. *17*, Syntype slide no. 2007, dorsal view of left valve showing outline. (p. 589)

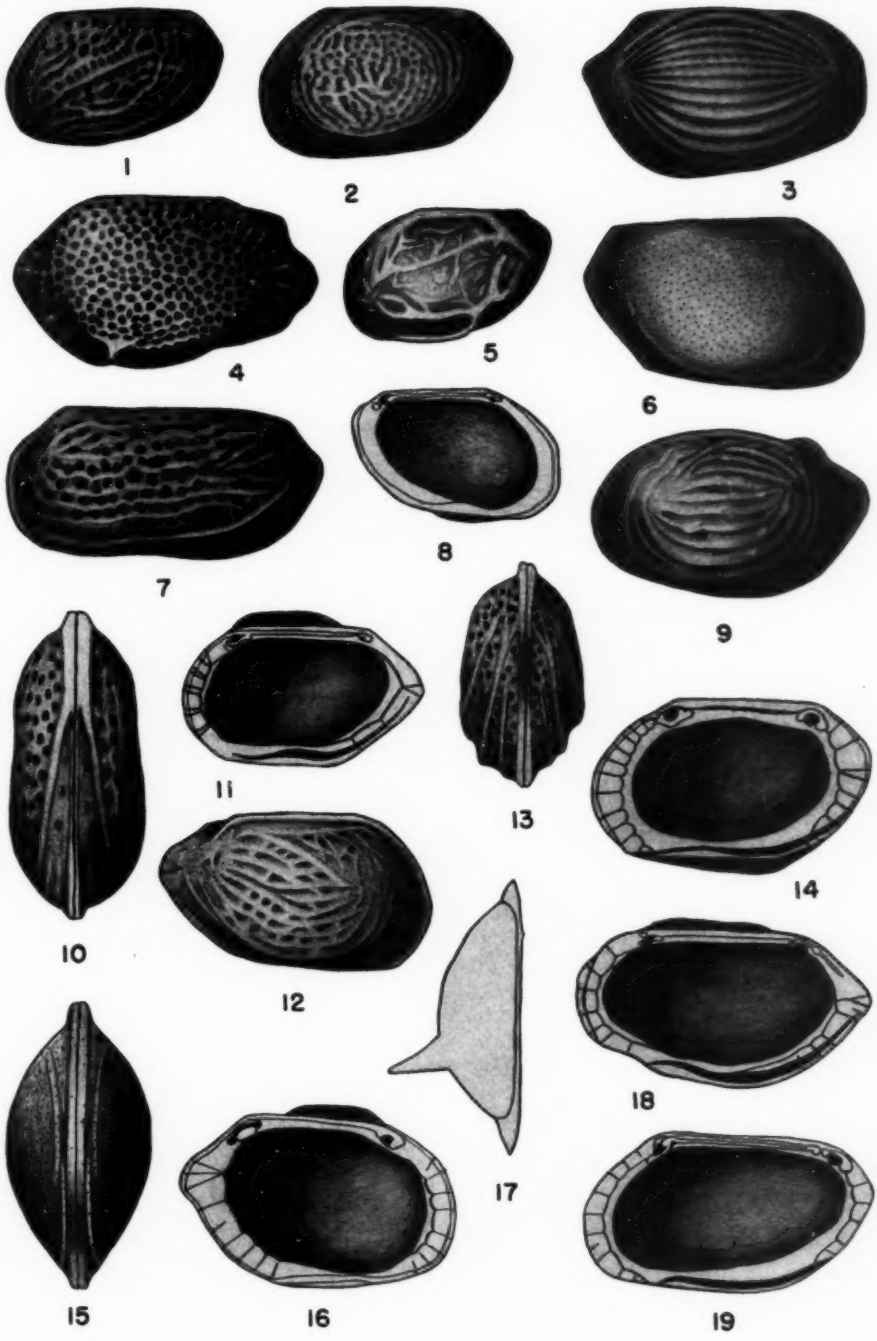
5, 8—*Loxoconcha surreala* Murray, n. sp., ×70. *5*, Syntype slide no. 2012, exterior view of left valve. *8*, Syntype slide no. 2012, interior view of left valve. (p. 590)

6, 15—*Loxoconcha howei* Murray, n. sp., ×70. *6*, Holotype slide no. 2010, exterior view of right valve. *15*, Holotype slide no. 2010, ventral view of entire carapace. (p. 592)

7, 10—*Loxoconcha mcbeanensis* Murray, n. sp., ×70. *7*, Syntype slide no. 2009, exterior view of left valve. *10*, Syntype slide no. 2009, ventral view of entire carapace. (p. 591)

9, 16—*Loxoconcha edwardsi* Murray, n. sp., ×70. *9*, Syntype slide no. 2013, exterior view of left valve. *16*, Syntype slide no. 2013, interior view of right valve. (p. 591)

11, 12—*Loxoconcha chamfera* var. *diverta* Murray, n. var., ×75. *11*, Syntype slide no. 2005, interior view of right valve. *12*, Syntype slide no. 2005, exterior view of right valve. (p. 592)



Murray, Tertiary (Eocene) Ostracoda

UNIV. OF MICH.

LOXOCONCHA EDWARDSI

Murray, n. sp.

Plate 68, figures 9, 16

Carapace subelliptical in lateral view; dorsal and ventral margins convex. Anterior end broadly rounded, slightly oblique. Posterior margin sloping abruptly from dorsal margin, curving gradually from ventral margin to caudal spine. Slight indentation between postero-dorsal angle and posterior extremity. Dorsal margin overlapped by surface ribs. Exterior ornamentation consists of 10 to 14 rounded ribs, converging in general toward anterior and posterior ends. Dorsally two to four ribs are diverted toward antero-ventral angle; some of the ribs bifurcate, others swell or possess tubercles. Troughs wider than ribs, rows of very small pits at bases of ribs. Interiorly, there is a broad marginal area, flanged ventrally. Line of concrescence distinctly indented at radial pore canals. Inner margin projects slightly. Pore canals about 8 to 10, anteriorly and posteriorly. Hinge consists in left valve of horseshoe-shaped socket open ventrally and partially encircling an elongate tooth. Dorsal to the socket there is a flange, which runs backward as a finely crenulate bar to two posterior teeth connected by a short bar so as to form a somewhat horseshoe-shaped tooth, open ventrally. Ventral to and partially encircled by these teeth is a small somewhat circular socket.

Dimensions of left valve, syntype slide no. 2013: length, 0.44 mm; width, 0.28 mm.

Remarks.—This species can be distinguished from *L. chamfera* by its fewer ribs, two rows of pits between ribs rather than one row, ventral and dorsal outlines, and divergence of ribs toward antero-ventral angle. It differs from *L. chamfera* var. *diverta* in dorsal and ventral marginal outlines, and in the absence of large, subangular pits between ribs. A noticeable but not confusing similarity to *L. cretacea* and *L. corrugata* is observable. *L. cretacea*, *L. corrugata*, *L. chamfera*, *L. chamfera* var. *diverta*, and *L. edwardsi* seem to be closely related species, probably derived from a common ancestor. Close study, however, indicates division into separate species which should be useful in correlation and zonation. *Loxoconcha edwardsi* is named in honor of Mr. and Mrs. R. A. Edwards, University of North Carolina.

Occurrence.—Type locality, Cane River formation, Louisiana Oil and Refining Company's Tremont no. 2 well, Urania field, LaSalle Parish, La., sec. 30, T. 10 N., R. 2 E., depth, 1,473 feet.

LOXOCONCHA MCBEANENSIS

Murray, n. sp.

Plate 68, figures 7, 10

Carapace fairly heavy, in side view very elongate, semi-quadrate. In dorsal view, flattened lens-shaped, each valve slightly concave centrally. Carapace thickest posterior to middle. Dorsal and ventral portions roughly parallel, each concave near transverse median line. Anterior end rounded with a slight indentation just ventral to antero-dorsal angle. Posterior end semirounded, indented just ventral to postero-dorsal angle. Short and blunt caudal spine present on posterior end. Surface ornamentation consists of rounded to angular pits tending toward arrangement in rows roughly parallel to dorsal and ventral margins, separated by irregular ridges. One or more somewhat serrate ridges especially prominent on ventral side. Entire carapace, viewed ventrally, is characterized by convergence of most prominent ridge on either valve with marginal ventral rim. Anterior portion of ventral marginal rim much broader than posterior portion. Depressed area just posterior to point of convergence of most prominent ridge and ventral marginal ridge. Hinge typical of genus.

Species characterized by greatly elongated form, by parallelism of rows of pits and of ridges, and by the ornamentary detail of the ventral portion of the carapace.

Dimensions of a complete carapace,

syntype slide no. 2009: length, 0.50 mm; height, 0.25 mm; thickness, 0.23 mm.

Remarks.—Species somewhat similar to *L. fletcheri* Israelsky (1929, 1935, Alexander 1936), from the Cretaceous of Texas and Arkansas. Ventral ornamentation and more ventral position of most prominent rib distinguish *L. mcbeanensis* from this form, however.

Occurrence.—Type locality, McBean formation, about one-half mile south of McBean Station, Ga., on south bank of McBean Creek, one-half mile upstream from bridge; H. V. Howe, collector.

LOXOCONCHA HOWEI
Murray, n. sp.
Plate 68, figures 6, 15

Carapace fragile, subquadrate. Dorsal margin straight; ventral margin convex, slightly indented posterior to transverse median line. Lens-shaped in dorsal view. Anterior end obliquely rounded, greatest obliquity ventral to longitudinal median line. Posterior end subangular with a blunt caudal spine just dorsal to the longitudinal median line. Gentle slope from ventral margin to spine, abrupt slope from dorsal margin to spine. Surface ornamentation consists of one to three ventrally located ridges roughly parallel to antero-ventral, ventral and postero-ventral margins, and of numerous, very small pits and bumps with a tendency toward arrangement in rows parallel to margins of carapace. Carapace appears smooth and polished under low magnification. Ventral view of entire specimen characterized by divergence of ribs from parallelism to ventral marginal rim, which is depressed just posterior to middle. Hinge typical of genus.

Dimensions of complete carapace, holotype slide no. 2010: length, 0.48 mm; height, 0.30 mm; thickness, 0.24 mm.

Remarks.—This species is distinctive because of its relative absence of surface ornamentation. The greater relative height and ventral ribs distinguish this species from *L. nuda* Alexander (1934), from the Midway of Texas. *Loxoconcha howei* is named in honor of Dr. H. V. Howe, Director, School of Geology, Louisiana State University.

Occurrence.—Type locality, Cook Mountain formation, 2 miles southeast of Minden, Webster Parish, La.; H. V. Howe, collector.

LOXOCONCHA CHAMFERA Murray var. DIVERTA Murray, n. var.
Plate 71, figures 11, 12

This variety differs from the typical form in the presence of large subangular to angular pits between ribs. These pits are larger and more irregular than those of the typical species. It differs also in the manner of divergence of ribs, in the special prominence of one or two ventral ribs, and in the more nearly parallel ventral and dorsal margins.

Dimensions of right valve, syntype slide no. 2005: length, 0.27 mm; height, 0.23 mm.

Occurrence.—Type locality, Cane River formation, Louisiana Oil and Refining Company's Tremont no. 2 well, Urania field, LaSalle Parish, La., sec. 30, T. 10 N., R. 2 E., depth, 1,468 to 1,487 feet.

EOCENE CLAIBORNE LOXOCONCHA LOCALITIES

In preparation of the paper, material from some 300 localities was examined. Species of *Loxoconcha* were found at the following localities:

1. J. H. Huner's Loc. 20, Cook Mountain formation. Road cut on east side of Louisiana State Highway 5 just north of Dodson, Winn Parish, La., 0.1 mi. north of the line between secs. 22 and 27, T. 13 N., R. 3 W.
2. J. H. Huner's Loc. 36, Cook Mountain formation. A ditch along Louisiana State Highway 6 up from creek on NW side of road in SW ¼ NE ¼ SE ¼ NE ¼ sec. 16, T. 10 N., R. 5 W., Winn Parish, La.
3. J. H. Huner's Loc. 50, Cook Mountain formation. Ditch on west side of Louisiana State Highway 480 about one-half mile south of Calvin, Winn Parish, La., in NE ¼ NW ¼ NE ¼ sec. 9, T. 11 N., R. 4 W.
4. J. H. Huner's Loc. 62, Cook Mountain formation. In ditch on NE side of Emergency Conservation Works Road

CHECK LIST OF CLAIBORNE SPECIES OF LOXOCONCHA
Numbers refer to localities listed at end of paper.

Locality	*Loxoconcha lisbonensis*	*Loxoconcha claibornensis*	*Loxoconcha chamfera*	*Loxoconcha chamfera* var. *diverta*	*Loxoconcha edwardsi*	*Loxoconcha unispinosa*	*Loxoconcha mcbeanensis*	*Loxoconcha howei*	*Loxoconcha surreala*
1	—	x	—	—	—	—	—	—	—
2	—	—	x	—	—	—	—	x	—
3	—	—	x	—	—	—	—	—	—
4	—	x	x	—	—	—	—	—	—
5	—	x	x	—	—	x	—	—	x
6	—	x	x	x	—	x	—	—	—
7	—	x	x	—	—	—	—	x	x
8	x	x	—	—	—	—	—	—	—
9	x	—	—	—	—	—	—	—	—
10	—	—	—	—	x	x	—	x	—
11	—	x	x	x	x	—	—	—	—
12	x	—	—	—	—	?	x	—	x
13	—	x	x	—	—	—	—	x	—
14	?	—	—	—	—	—	—	—	—
15	—	—	x	—	—	—	—	—	—
16	—	x	—	—	—	—	—	—	—
17	—	x	x	—	—	—	—	—	—
18	—	x	x	—	—	—	—	—	—
19	—	x	—	—	—	—	—	x	—
20	—	x	—	—	—	—	—	—	—
21	—	—	x	—	—	—	—	—	—
22	—	x	—	—	—	—	—	—	—
23	—	x	x	x	x	—	—	—	—
24	—	—	x	—	—	—	—	—	—
25	—	x	—	—	—	—	—	—	—
26	—	—	x	—	—	—	—	—	—
27	x	—	—	—	—	—	—	—	—
28	—	—	x	—	—	—	—	—	—
29	—	x	—	—	?	—	—	—	—
30	—	x	x	—	—	—	—	—	—
31	—	x	x	—	—	—	—	—	—
32	—	x	x	—	—	—	—	—	—
33	—	x	—	—	—	—	—	—	x
34	—	x	—	—	—	—	—	x	—
35	—	x	x	—	—	—	—	—	—
36	—	x	x	—	—	—	—	—	—
37	—	x	—	—	—	—	—	—	—
38	—	x	—	—	—	—	—	—	—
39	—	x	—	—	—	—	—	—	—
40	—	x	—	—	—	—	—	—	—
41	—	x	x	—	—	—	—	—	—
42	—	x	x	—	—	—	—	—	—
43	—	x	x	—	—	—	—	—	—
44	—	x	—	—	—	—	—	—	—
45	—	x	x	—	—	—	—	—	—
46	—	x	x	—	—	—	—	—	—
47	—	x	—	—	—	—	—	?	—

No. 21 on slope leading down to Couley Creek, Winn Parish, La., in SE ¼ NE ¼ NE ¼ sec. 22, T. 10 N., R. 2 W., 18 inches above base of slope.

5. J. H. Huner's Loc. 99, Cook Mountain formation. Along C.C.C. tram line road, about 2½ miles west of Calvin, from creek crossing road, Winn Parish, La., in SE ¼ NW ¼ SE ¼ sec. 7, T. 11 N., R. 4 W.
6. J. H. Huner's Loc. 111, Cook Mountain formation. Ditch leading to creek on south side of the lower Dodson road in Winn

Parish, La., in NE ¼ SW ¼ SW ¼ sec. 28, T. 13 N., R. 3 W., upper 2 feet of 12 foot bed.

7. Cane River formation, *Discocyclina advena* zone. Ethridge No. 1 wildcat well near Colfax, Grant Parish, La., 600 feet south, 300 feet west in NW cor. sec. 19, T. 7 N., R. 3 W., depth of cores, 2,411 to 2,452 feet.
8. E. A. Smith's bed 14, Lisbon formation, Claiborne Bluff, Ala.
9. *Ostrea sellaeformis* bed, Lisbon formation, Coffeeville, Ala.
10. J. B. Garrett's Loc. 18, Cook Mountain formation. Behind Speight's at Columbus, Sabine Parish, La.
11. Urania oil field, Cane River formation, LaSalle Parish, La. Louisiana Oil and Refining Company's Tremont No. 2 well, sec. 30, T. 10 N., R. 2 E. Depth, 1,468 to 1,481 feet.
12. H. V. Howe's Loc. 203, McBean formation. About one-half mile south of McBean Station, Ga., on south bank of McBean Creek, one-half mile upstream from bridge.
13. H. V. Howe's Loc. 258, Cook Mountain formation. Road cut 2 miles southeast of Minden on Highway No. 80 to Arcadia, Webster Parish, La.
14. Urania oil field, Cane River formation, LaSalle Paris, La. Louisiana Oil and Refining Company's Tremont No. 1 well, sec. 30, T. 10 N., R. 2 E. Depth, 1,506 to 1,508½ feet.
15. H. V. Howe's Loc. 60 and 99, Cook Mountain formation. Beds 3 and 4, St. Maurice, Winn Parish, La., N. ½ NE ¼ sec. 17, T. 12 N., R. 2 W.
16. Weches formation, 1,000 feet west of bridge at Smithville, Tex., 10 feet above low water level. R. R. Copeland, Jr., collector.
17. Cheneyville oil field, Rapides Parish, La. Amerada Petroleum Company's Weil No. 1 well, 3,003 feet from south line and 495 feet from west line sec. 53, T. 1 S., R. 2 E. Depth, 6,510 to 6,549 feet.
18. H. V. Howe's Loc. 238, Weches formation. Five miles west of San Augustine, Tex., on highway to Nacogdoches, San Augustine County.
19. Stadnichenko Loc. II, Cook Mountain formation. Evergreen Crossing of Elm Creek 5 miles north of Giddings, Lee County, Tex., A. D. Ellis, Jr., collector.
20. Mosley's Ferry, Brazos County, Tex.
21. H. V. Howe's Loc. 271. Type locality of Enterprise green marl, Banks of Chickasawhay River at Enterprise, Clarke County, Miss., B. W. Blandpied, collector.
22. Little Brazos River, 200 yards north of old bridge on Highway 21 between Bryan and Stone City, Tex.
23. Cane River formation, Urania oil field, LaSalle Parish, La. Louisiana Oil and Refining Company's Tremont No. 2 well, sec. 30, T. 10 N., R. 2 E. Depth, 1,497 to 1,509 feet.
24. J. H. Huner's Loc. 367, Cook Mountain formation. Taken in ditch 1 foot deep from hole 6½ feet deep, Winn Parish, La. NE cor. SE ¼ SE ¼ sec. 7, T. 11 N., R. 4 W., on the SW. side of C.C.C. road between Louisiana 9 and Louisiana 480.
25. J. Rukas' Loc. 214, Cook Mountain formation. Brown clays with organic material containing very fossiliferous concretions, SW ¼ sec. 9, T. 7 N., R. 8 W., on Route 39, Natchitoches Parish, La.
26. J. Rukas' Loc. 463, Cane River formation (oyster bed), 1.4 miles north of Provencal on Provencal-Hagewood road and 0.2 miles east of road in creek bed, Natchitoches Parish, La.
27. J. Rukas' Loc. 274-C, Cook Mountain formation, 250 feet upstream (west) of bridge 4.9 miles north of Flora, Natchitoches Parish, La.
28. J. Rukas' Loc. 207, Cook Mountain formation—*Siphoninella* zone, 2.8 miles south of Provencal on Highway No. 39, Natchitoches Parish, La.
29. J. Huner's Loc. 82, Cook Mountain formation. Ditch about 100 yards north of the forestry building at C.C.C. camp on Louisiana Highway 480, Winn Parish, La., in the NE ¼ SE ¼ sec. 33, T. 11 N., R. 4 W. Weathered calcareous clay or marl, with greensand.
30. J. Huner's Locs. 95 and 96, Cook Mountain formation. Road cut on southeast side of Louisiana Highway 6 at intersection of Louisiana 6 and road to St. Maurice, Winn Parish, La., in NW ¼ NW ¼ SE ¼ NE ¼ sec. 20, T. 10 N., R. 5 W., 22 to 23 feet below top of slope.
31. J. Huner's Loc. 113, Cook Mountain formation. Ditch leading to creek branch on south side of lower Dodson road, Winn Parish, La. in the NE ¼ SW ¼ sec. 28, T. 13 N., R. 3 W.
32. J. Huner's Loc. 98, Cook Mountain formation. Creek crossing C.C.C. tram line road about 2½ miles west of Calvin, Winn Parish, La., in SE ¼ NW ¼ sec. 7, T. 11 N., R. 4 W.
33. J. Huner's Loc. 59, Cook Mountain formation. Along logging road southeast from Emergency Conservation Works road, Winn Parish, La., in the SW ¼ NE ¼ SW ¼ sec. 15, T. 10 N., R. 5 W.
34. J. Huner's Loc. 94, Cook Mountain formation. Along C.C.C. road from Louisiana 6 to Cedar Bluff on Saline Bayou, Winn Parish, La., in SW ¼ SE ¼ SE ¼ sec. 17, T. 10 N., R. 5 W.
35. J. Huner's Loc. 116, Cook Mountain formation. Along Louisiana 1112 in ditch on

west side of road 0.1 mile south of Gansville, Winn Parish, La., in SE cor. SE ¼ SW ¼ sec. 1, T. 13 N., R. 4 W.

36. Urania oil field, Cane River formation, LaSalle Parish, La. Louisiana Oil and Refining Company's Tremont No. 2 well, sec. 30, T. 10 N., R. 2 E. Depth, 1,539 to 1,546 feet.
37. J. Huner's Loc. 107, Cook Mountain formation. In ditch on southwest side of Emergency Conservation Works Road 109, Winn Parish, about 2½ miles southwest of Dodson, La., in NW ¼ NW ¼ SW ¼ sec. 5, T. 12 N., R. 3 W.
38. J. Huner's Loc. 110, Cook Mountain formation. Ditch on south side of C.C.C. road in NE ¼ NW ¼ NW ¼ NE ¼ sec. 7, T. 12 N., R. 3 W., Winn Parish, La.
39. J. Huner's Loc. 39, Cook Mountain formation. Field one-fourth mile south of Louisiana Highway, Winn Paris, La., in SW ¼ NE ¼ NW ¼ sec. 8, T. 11 N., R. 4 W.
40. J. Huner's Loc. 208, Cook Mountain formation. Gully up from creek on south side of Lower Dodson road in NW cor. SW ¼ SW. ¼ SW. ¼ sec. 28, T. 13 N., R. 3 W., Winn Parish, La., from drill hole 5 feet deep.
41. J. Huner's Loc. 212, Cook Mountain formation. Drill hole 10 feet west of Louisiana 5, Winn Parish, La., in SE cor. NW ¼ NW ¼ SE ¼ sec. 5, T. 13 N., R. 3 W. Depth, 17½ feet.
42. J. Huner's Loc. 233, Cook Mountain formation. Gully up from creek on south side of Louisiana 6 in NE cor. of NW ¼ NE ¼ SW ¼ sec. 20, T. 10 N., R. 5 W., Winn Parish, La.
43. J. Huner's Loc. 216, Cook Mountain formation. Type Milams section on scarp on southwest side of Antoine creek in SW ¼ NE ¼ sec. 17, T. 13 N., R. 3 W., Winn Parish, La.
44. J. Huner's Loc. 226, Cook Mountain formation. Ditch on south side of Couley road on slope about 4 feet above the top of marl, NW cor. NE ¼ NW ¼ SW ¼ sec. 2, T. 10 N., R. 5 W., Winn Parish, La.
45. J. Huner's Loc. 209, Cook Mountain formation. Gully up from creek on south side of Lower Dodson road, Winn Parish, La., NE cor. SW ¼ SW ¼ SW ¼ sec. 28, T. 13 N., R. 3 W.
46. Urania oil field, LaSalle Parish, La., Cane River formation. Louisiana Oil and Refining Company's Tremont No. 2 well, sec. 30 T. 10 N., R. 2 E. Depth, 1,551 to 1,553 feet.
47. Stadnichenko Loc. I. Orell's Crossing, Elm Creek, 5.2 miles northwest of Giddings, Lee County, Tex.

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OSTRACODA FROM THE MAUCH CHUNK (MISSISSIPPIAN) OF WEST VIRGINIA

H. N. CORYELL AND I. G. SOHN

ABSTRACT

The ostracodes included here are from the upper part of the Reynolds member of the Bluefield formation of the Mauch Chunk (upper Mississippian). They are classified in nine genera and thirteen species. Eleven of the species and four of the genera are new.

This paper is one of a series of studies conducted in the Micropaleontological Laboratory of Columbia University, to investigate the microfaunas of the upper Mississippian rocks. It is hoped that a knowledge of the microfaunas will aid in a better understanding of upper Mississippian stratigraphy of the Appalachian and Mid-Continent regions. Recent petroleum developments in the Mid-Continent make such a study desirable.

With this object in mind, samples of the upper Bluefield beds of West Virginia were examined, and a group of characteristic species were described and illustrated. The samples were collected by Dr. H. N. Coryell and Mr. Dana Wells in 1936 from Greer quarry, a limestone quarry located about 6½ miles southeast of Morgantown, W. Va. Since there have been very few previous studies of upper Mississippian Ostracoda, it is not surprising that most of the species found here are new.

We wish to thank Miss Doris S. Malkin for reading the manuscript and Miss Miriam B. Pollak, who drew the illustrations for the paper.

The Greer quarry supplies a large amount of rock from the Greenbrier limestone for fertilization and road work. The quarry was at first worked by stripping the overburden, but the overburden is now so thick that it is more economical to work underground by the room-and-pillar method. The bed from which this faunule is described is a 6-inch layer of dark calcareous shale, 4 inches from the top of the Reynolds member of the Mauch Chunk shale, which comprises the overburden. The position of this layer and its relation to the other beds is shown on the accompanying stratigraphic column (fig. 1).

At the Greer quarry much of the Mauch Chunk is of marine origin and consists of alternating beds of shale and limestone, with an occasional sandstone bed, these beds grading northward and eastward into red beds. The alternating lithologies indicate that the position of the land mass with relation to sea level oscillated up and down so that this locality was sometimes receiving fine sediment and sometimes coarse sediment.

The bed from which this faunule is described has been listed as an *Aviculopecten* zone, containing the pelecypod genera *Leda*, *Aviculopecten*, *Allorisma*, and *Sphenoltus*.

We have both lithologic and paleontologic reasons, therefore, to infer that the site of the Greer quarry locality was, at the time this Ostracoda faunule lived, some distance from shore, not deeper than 200 fathoms. The faunule should, therefore, be somewhat cosmopolitan in its facies, rather than a provincial one, and it may be expected that the same or closely related species might be found quite widely distributed.

The Ostracoda fauna at Greer quarry is characterized by an abundance of specimens of *Sansabella*, *Persansabella*, *Geffenina* and *Geffenites*. Other genera are more sparsely represented. The following species are included in this paper:

Persansabella bradfieldi Coryell and Sohn, n. gen., n. sp., *Sansabella whitei* Bradfield, *Sansabella tumida* Coryell and

Sohn, n. sp., *Geffenina marmerae* Coryell and Sohn n. gen., n. sp., *Geffenina johnsoni* Coryell and Sohn, n. sp., *Geffenites jungae* Coryell and Sohn n. sp., *Geffenites mammoides* Coryell and Sohn, n. sp., *Nuferella wellsi* Coryell and Sohn. sp., *Microcoelonella scanta* Coryell and Sohn, n. gen., n. sp., *Amphissites monamastadis* Coryell and Sohn, n. sp., *Glyptopleura schizopleura* Coryell and Sohn, n. sp., *Healdia bluefieldana* Coryell and Sohn, n. sp., and *Healdia simplex* Roundy

SYSTEMATIC DESCRIPTIONS

Phylum ARTHROPODA

Class CRUSTACEA

Order OSTRACODA Latreille

Family LEPERDITELLIDAE Ulrich and Bassler, 1906

Genus MICROCOELONELLA Coryell and Sohn, n. gen.

Carapace small, leperditioid in lateral view; valves convex, unequal; right valve larger, overlapping the left on the free margin; dorsal margin in lateral view, arched centrally; the hinge line depressed into a canoe-shaped channel; surface smooth.

Genotype, *Microcoelonella scanta* Coryell and Sohn, n. sp.

Remarks.—This genus resembles *Coelonella* Stewart in the elliptical dorsal view, dorsal channel, and in the type of overlap. It is distinctly smaller, more rectangular in lateral view and differs in the location of the dorsal marginal convexity. *Microcoelonella* has a reverse order of overlap when compared to *Sansabella* Roundy, and also differs in that the dorsal channel is canoe-shaped, rather than abruptly terminated by the overlapping valve, and in the apparent dorsal, marginal convexity in the lateral view. The regular convexity of the valves differentiates it from *Schmidtella* Ulrich.

MICROCOELONELLA SCANTA Coryell and Sohn, n. sp.
Plate 69, figures 1*a*, *b*

Carapace somewhat leperditioid in lateral view; dorsal margin arcuate; ventral margin rounded; cardinal angles obtuse; anterior margin rounded, with greatest extent centrally located; posterior margin narrowly rounded, greatest

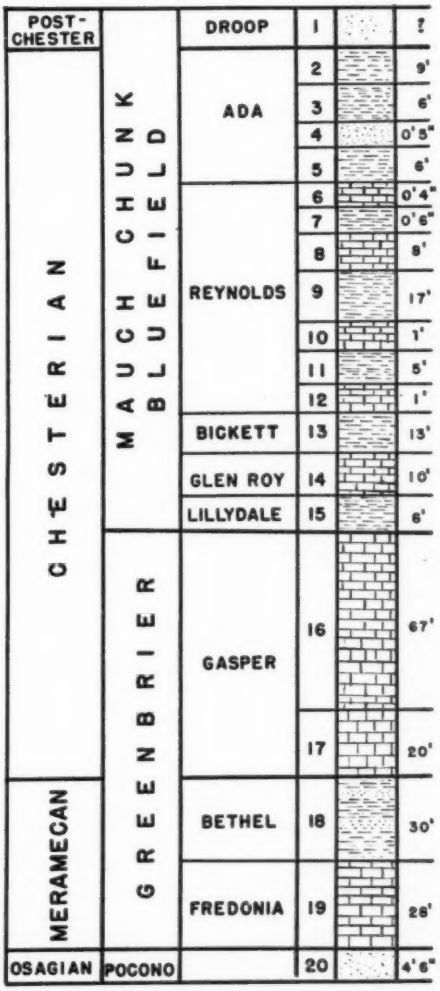


FIG. 1.—Columnar section at Greer quary (after J. L. Tilton, 1928) showing the position of bed no. 7 from which the ostracodes were collected.

extent above midheight; greatest height slightly posterior to the center, greatest thickness dorso-posterior to the center. Dorsal view, ellipsoidal, dorsal margin

reflexed to form a canoe-shaped depression along the hinge line; hinge line straight and equal to about seven-eighths of the length of the carapace. Right valve larger, overlapping the left strongly along the free margin. Valves convex, greatest in the dorso-central part; surface smooth.

The type specimen is a complete carapace; its hinge structure was not observed. Length 0.50 mm, height 0.30 mm, thickness 0.25 mm.

Holotype, Columbia Univ. Micropaleontological Collection.

Superfamily BEYRICHIACEA
Ulrich and Bassler, 1923

Family KLOEDENELLIDAE
Ulrich and Bassler, 1923

Genus PERSANSABELLA
Coryell and Sohn, n. gen.

Carapace small, less than 2 mm in length; outline, subrectangular; cardinal angles obtuse, greatest thickness in the anterior half; right valve larger, overlaps the left on the free margin; hinge line straight, slightly lower than the dorsal margin, giving an excavated or channeled appearance in the dorsal view of a complete specimen. Hinge structure consists of a longitudinal groove and tongue on each valve. A pit extending into a shallow sulcus, is located posterior to the center.

Genotype, *Persansabella bradfieldi* Coryell and Sohn, n. sp.

Remarks.—This genus differs from *Sansabella* in that the overlap is reversed, the right valve being the larger. It differs from *Kirkbyina* Ulrich and Bassler in having a channeled dorsum and grooved hinge structure. *Coelonella* Stewart differs from this genus in not having a pit.

Sansabella reversa Morey (1935) and *Kirkbyina laevis* Warthin (1930) should be placed in this genus.

PERSANSABELLA BRADFIELDI
Coryell and Sohn, n. sp.
Plate 69, figures 2*a*, *b*

Kirkbyina laevis (Warthin). BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, p. 44, pl. 3, figs. 3*a*, *b*.

Sansabella laevis (Warthin). JOHNSON (part), *1936*. Nebraska Geol. Survey, Paper No. 11, pp. 11, 12, pl. 5, fig. 13.

Carapace semiovate in lateral view; dorsal margin straight; ventral margin convex; anterior cardinal angle obtuse; anterior margin rounded, greatest extension above midheight; posterior cardinal angle less obtuse than anterior; posterior margin of right valve rounded; posterior contact with left valve obliquely truncated dorsally, with blunt acumination slightly below midheight; dorsal view ellipsoidal, thinning posteriorly. Dorsal

EXPLANATION OF PLATE 69

FIGS. *1a*, *b*—*Microcoelonella scanta* Coryell and Sohn, n. gen., n. sp., holotype. *a*, Left view, ×76; *b*, dorsal view, showing canoe-shaped channel, ×76. (p. 597)

2a, *b*—*Persansabella bradfieldi* Coryell and Sohn, n. gen., n. sp., holotype. *a*, Left view, ×40; *b*, dorsal view, ×40. (p. 598)

3—*Sansabella whitei* Bradfield, right view of hypotype, ×40. (p. 599)

4a, *b*—*Sansabella tumida* Coryell and Sohn, n. sp., holotype. *a*, Right view, ×40; *b*, dorsal view showing posterior apophysis, ×40. (p. 599)

5a, *b*—*Geffenina marmerae* Coryell and Sohn, n. gen., n. sp., holotype. *a*, Right valve, ×43; *b*, dorsal view, ×40. (p. 600)

6—*Geffenina johnsoni* Coryell and Sohn, n. sp. Right view of holotype, ×40. (p. 600)

7—*Geffenites jungae* Coryell and Sohn, n. sp. Left valve, holotype, ×43. (p. 601)

8—*Geffenites mammoides* Coryell and Sohn, n. sp. Right valve, holotype, ×43. (p. 601)

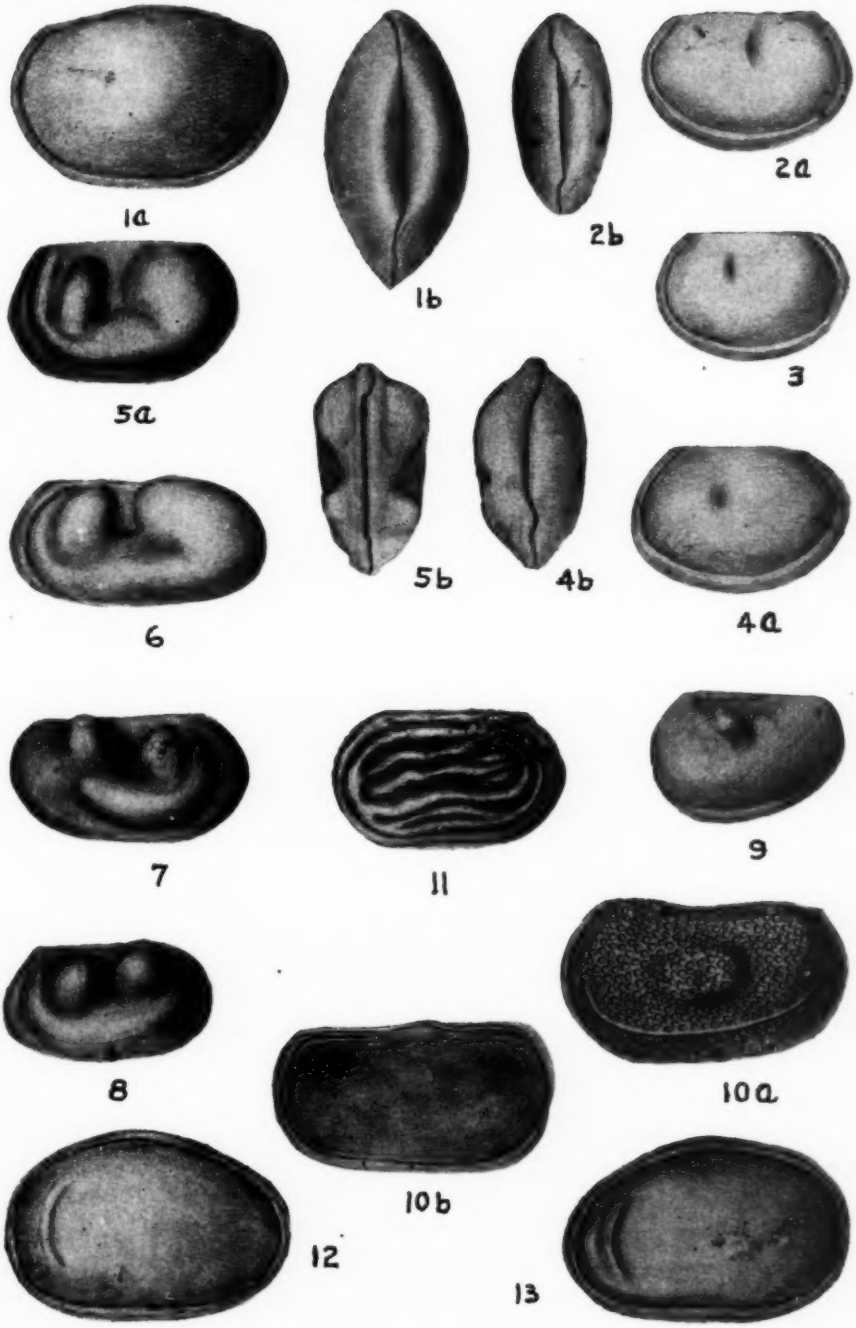
9—*Nuferella wellsi* Coryell and Sohn, n. sp. Right view of holotype, ×40. (p. 602)

10a, *b*—*Amphissites monomastadis* Coryell and Sohn, n. sp., holotype. *a*, Right valve, ×75; *b*, interior of the same, showing the relation of the marginal keel to the contact margin. (p. 602)

11—*Glyptopleura schizopleura* Coryell and Sohn, n. sp. Right valve, holotype. (p. 603)

12—*Healdia simplex* Roundy. Left view, hypotype, ×78. (p. 603)

13—*Healdia bluefieldana* Coryell and Sohn, n. sp. Left view of holotype, ×71. (p. 603)



Coryell and Sohn, Mississippian Ostracoda

UNIV. OF MICH.

margins reflexed to form a V-shaped channel along the hinge line; hinge line about two-thirds the length of valve. Hingement consists of a sansabelloid groove and tongue arrangement. Greatest thickness in the anterior two-thirds above midheight; greatest height in anterior half. Right valve larger, overlaps the left on the free margin; valves channeled along the dorsum. A shallow pit is located above midheight and posterior to the center. This pit continues dorsally as a shallow sulcus.

Length, 0.775 mm; height, 0.50 mm; thickness, 0.375 mm.

Remarks.—This species differs from *Persansabella laevis* (Warthin), 1930, and from specimens of that species described by Coryell and Sample in 1932, in that their species shows a flangelike marginal area. Johnson in 1936 placed *Kirkbyina laevis* Bradfield and *Sansabella whitei* Bradfield in synonymy with *Sansabella laevis* (Warthin), and described some of the specimens as having a marginal flange. Those specimens without the flange and with the right valve overlapping the left should be placed in *Persansabella bradfieldi*.

Type.—Holotype, Columbia Univ. Micropaleontological Collection.

Geuus SANSABELLA Roundy, 1926
SANSABELLA WHITEI Bradfield, 1935
Plate 69, figure 3

Sansabella whitei BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, pl. 3, figs. 2*a*, *b*.

Sansabella laevis (Warthin). JOHNSON (part), *1936*, Nebraska Geol. Survey, Paper no. 11, pp. 11, 12, pl. 5, figs. 11, 12, 14, 15.

Carapace subovate; dorsal margin straight; ventral margin convex; anterior cardinal angle obtuse; anterior margin obliquely truncated in the dorsal half and rounding into the ventral margin below the midheight; greatest extension of anterior above middle. Posterior cardinal angle less obtuse than the anterior cardinal angle; posterior margin more rounded below than above the midheight, with greatest extension below the midheight of the valve. Left valve larger and overlaps the right.

Length 0.75 mm, height 0.50 mm, thickness 0.375 mm.

Hypotype, Columbia Univ. Micropaleontological Collection.

SANSABELLA TUMIDA
Coryell and Sohn, n. sp.
Plate 69, figure 4*a*, *b*

Carapace subrhomboidal in lateral view; dorsal margin straight; ventral margin arcuate; anterior cardinal angle obtuse; anterior margin obliquely truncated dorsally, narrowly rounding into the ventral margin, with greatest extension of anterior above midheight. Posterior cardinal angle less obtuse than anterior; posterior margin broadly rounded above and narrowly curved into the ventral margin; greatest extension of posterior below midheight. Dorsal view subrhomboidal, thinning posteriorly; dorsal edges reflexed to form a V-shaped channel along the hinge contact; hinge line about two-thirds the length of the valves. Left valve larger, overlaps the right along the free margin. A toothlike apophysis of the left valve extends over the right at the posterior end of the hinge line, marking the posterior termination of the grooved channel, which is limited anteriorly by the overlap. An indistinct pit is present above the midheight and posterior to the center. The dorso-anterior halves of both valves are tumid, and projecting above the margins of the channeled dorsum. Convexity of the valves is irregular, forming a gently sloping flange near the end margins.

Length, 0.70 mm; height, 0.49 mm; thickness, 0.39 mm.

Remarks.—This species differs from *S. whitei* Bradfield, in the protruding tumidity, subrhomboidal outline, and the toothlike posterior dorsal apophysis.

Type.—Holotype, Columbia Univ. Micropaleontological Collection.

Genus GEFFENINA Coryell and Sohn, n. gen.

Carapace subelliptical in lateral view; dorsal margin straight; ventral margin

straight or broadly convex; and margins rounded. Greatest thickness near the anterior end. Left valve larger, overlaps the right along free margin. Surface of valve marked by a distinct node near the central portion of the posterior half, which is bordered on the posterior and ventral sides by a submarginal ridge that enlarges forward and merges into the hook-like convexity of the anterior half of the valve. A distinct median sinus separates the anterior swelling from the posterior node. Hingement is sansabelloid. Surface is smooth or finely granulose.

Genotype, *Geffenina marmerae* Coryell and Sohn, n. sp.

GEFFENINA MARMERAE
Coryell and Sohn, n. sp.
Plate 69, figure 5*a*, *b*

Carapace subrhomboidal in lateral view. Dorsal and ventral margins subparallel; anterior margin rounded, greatest extension above the midheight; posterior margin oblique, curving into the ventral margin with greatest extension below midheight. Dorsal view is somewhat wedge-shaped with the greatest thickness in the anterior half. Height averages about two-thirds of the greatest length; valves unequal, left valve larger, overlapping the right on the free margin. Surface smooth or granulose. The anterior convexity is a broad swelling, rising slightly above the hinge line, broadly confluent with the ventral ridge, from which it is partly separated by an indistinct antero-ventral branch of the submedian vertical sulcus. Posterior node is elliptical, with its greatest diameter slightly oblique postero-ventrally and equal to about half the height of the carapace. The node is situated somewhat below the dorsal margin at a distance of about one-fourth of the length of the valve from the posterior end. Ventral ridge is broadly curved, decreasing in width posteriorly and separated from the posterior node by a continuation of the sulcus. Farther backwards it thins, curves dorsally around the node, lies subparallel to the posterior margin and terminates near the posterior cardinal angle.

Length 0.75 mm, height 0.55 mm, thickness 0.44 mm.

Holotype, Columbia Univ. Micropaleontological Collection.

GEFFENINA JOHNSONI
Coryell and Sohn, n. sp.
Plate 69, figure 6

Carapace subovate in lateral view; dorsal and ventral margins subparallel; anterior margin narrowly arcuate; posterior margin more broadly curved; greatest length at midheight. Anterior cardinal extremity rounded; posterior cardinal margin obtusely angulated; dorsal view wedge-shaped, thinning posteriorly. Anterior convexity forms a broad swelling flush with the hinge line, occupying the whole anterior of the valve; posterior node elliptical, located slightly below the dorsal margin near the center of the posterior half of the valve; greatest diameter of the node is about two-thirds of the height of the valve. The ventral ridge is broadly rounded centrally, while anteriorly it merges with the convexity, and posteriorly it becomes quite narrow as it curves along subparallel to the posterior margin, terminating near the top of the posterior node. A broad, deep sulcular depression is located behind the center of the valve and bifurcates ventrally, the posterior branch of which continues around the posterior node separating it from the ridge. Posterior margin is bordered by a flat, narrow area which is confluent dorsally with the median sinus.

Length, 0.80 mm; height, 0.40 mm.

Remarks.—This species differs from *G. marmerae* in that the flattened ventral and anterior marginal areas are absent, and the posterior node is larger, reaching higher dorsally in *G. johnsoni; G. marmerae* is shorter and higher than *G. johnsoni.*

Type.—Holotype, Columbia Univ. Micropaleontological Collection.

Genus GEFFENITES
Coryell and Sohn, n. gen.

Carapace inequivalve, left larger than the right, and overlapping along the free

margin; dorsal margin straight; hingement is sansabelloid; ventral margin is broadly convex; surface is marked by large anterior and posterior node-like swellings bordered along the free margin, or a portion of the free margin, by a ventral ridgelike swelling separated distinctly by depressions that merge centrally into the median vertical sinus. The surface texture is smooth or finely granulose.

Genotype, *Geffenites jungae* Coryell and Sohn, n. sp.

Remarks.—This genus differs from *Geffenina* in the presence of a somewhat hemispherically shaped node in the posterior portion of the anterior half of the valve and in the relationship of the ventral ridge to the anterior convexity.

GEFFENITES JUNGAE
Coryell and Sohn n. sp.
Plate 69, figure 7

Carapace semiovate; dorsal margin straight; ventral margin gently arcuate; anterior cardinal extremity narrowly rounded and the posterior broadly curved; the anterior ventral margin is truncated, producing a backward swing; posterior margin evenly rounded, with greatest extension near the midheight; greatest height posterior to center. Surface finely granular; anterior node entirely above midheight, occupying the dorso-posterior quarter of the anterior of the valve. The node is inflated, with the greatest tumidity in the dorsal part and sloping more gently posteriorly and ventrally. Posterior node is located farther below the dorsal margin than anterior node, and is also somewhat less prominent. The ventral ridge is distinct and rounded. It rises below the center of the anterior node and narrows posteriorly, curving dorsally around the posterior node, terminating before reaching the dorsal margin. A short, broad, centrally located sinus is present. The free margin is bordered by a narrow flangelike area. This species was named in honor of Miss Dorothy Jung.

Length, 0.80 mm; height, 0.45 mm.

Holotype, Columbia Univ. Micropaleontological Collection.

GEFFENITES MAMMOIDES
Coryell and Sohn, n. sp.
Plate 69, figure 8

Carapace subovate; dorsal margin straight; ventral margin gently arcuate; anterior cardinal margin rounded; anterior margin evenly rounded with the greatest extension at midheight; posterior cardinal angle obtuse; posterior margin obliquely truncated dorsally and broadly rounded into the ventral margin, with the greatest extension below midheight; greatest height anterior to center; the hemispherical anterior node occupies the posterior half of the dorso-anterior quarter of the valve; the posterior node is located near the center of the posterior half; it is subhemispherical with the elongation nearly perpendicular to the dorsal margin. The ventral ridge is broadly rounded, and rises steeply from the convexity of the valve antero ventrally to the anterior node. It lies adjacent to the margin in the midventral area, where it narrows and curves dorsally about the posterior node, leaving a narrow area of the valve surface posterior to the ridge. The free margin is bordered by a narrow flange.

Length, 0.70 mm; height, 0.40 mm.

Remarks.—This species is shorter and lower than *G. jungae*, with a narrower marginal area, and a distinctly different curvature of the anterior and posterior margins.

Type.—Holotype, Columbia Univ. Micropaleontological Collection.

Genus NUFERELLA
Bradfield, 1935

Genotype, *Nuferella infrequens* BRADFIELD, *1935*, Bull. Am. Paleontology, vol. 22, no. 73, p. 46, pl. 3, figs. 4*a*, *b*.

Bradfield (1935) considers the thicker end of *Nuferella* posterior and orients this genus so that the right valve is the larger. In this paper *Nuferella* is oriented with the left valve the larger, which gives emphasis to its leperditioid outline, posi-

tion of the sulcus, and presence of a tubercle near one of the cardinal angles in *N. wellsi*, discounting the possible importance of the location of the greatest gibbosity.

NUFERELLA WELLSI
Coryell and Sohn, n. sp.
Plate 69, figure 9

Carapace leperditioid in lateral view; dorsal margin straight; ventral margin curved; anterior margin highly arcuate with the greatest extension above midheight; posterior margin is broadly rounded, with the greatest extension below the midheight; the greatest height is near the middle of the posterior half. A deep elongate sulcus, terminating ventrally in a large circular pit, is centrally located above the midheight. The pit is bordered postero-dorsally by a small but distinct node, and anterodorsally by a nodelike extension of the convexity of the valve. The sulcus broadens dorsally into a low area that extends to the dorsal margin and posteriorly almost up to the cardinal angle. A small tubercle is present just below the anterior cardinal angle. Left valve is larger, overlapping the right along the free margins. Ventral overlap strongly pronounced, becoming less distinct along the end margins. Surface smooth to finely granulose.

Length, 0.60 mm; height, 0.40 mm; thickness, 0.30 mm.

Remarks.—This species is larger than *N. infrequens* Bradfield and differs from it in the manner of curvature of the anterior margin, and in the presence of the antero-dorsal nodelike extension of the convexity of the valves at the sulcus.

Type.—Holotype, Columbia Univ. Micropaleontological Collection.

Family KIRKBYIDAE
Ulrich and Bassler, 1906
Genus AMPHISSITES Girty, 1910

AMPHISSITES MONOMASTADIS
Coryell and Sohn, n. sp.
Plate 69, figure 10*a*, *b*

Carapace subrhomboidal; hinge line straight and gently converging anteriorly toward the ventral margin; anterior margin is truncated dorsally, making an obtuse angle with the dorsal margin and curving into the ventral margin to produce a backward swing; posterior cardinal angle more obtuse than the anterior; posterior margin regularly and broadly curved into the ventral margin. Greatest height is located about one-fourth from the posterior margin; greatest length is near midheight; dorsal view wedge-shaped, thinning posteriorly. Surface of valve is reticulated; marginal keel is prominent, parallel to and protruding beyond the contact margin, converging with the contact margins along the ends; hinge line grooved along the dorsal margin of the right valve. On the ventral surface of the valve, subparallel to the free margin, from which it is separated by a steep slope of the surface of valve, is a thin, conspicuous ridge; along the anterior slope it becomes faint as it converges with the anterior truncated margin. Posteriorly, this ridge merges into the reticulated surface of the valve just above the posterior ventral curve. A protruding subelliptical node is centrally located. Its greatest diameter is subparallel to the length of the valve; posteriorly, it is defined by a gentle slope and anteriorly by a steep one; the central node is separated from the anterior node by a sulcus that grades ventrally into an elongate pit. The anterior node is flush with the hinge line. An indistinct ridge originates at the posterior dorsal margin and grades ventrally into the surface of the valve.

Length, 0.52 mm; height, 0.28 mm.

Remarks.—This species differs from *Amphissites nodosus* Roth in that the marginal keel extends beyond the contact margin as seen in lateral view and the surface of the valve between the marginal and second keel is reticulated. The central node is located above the center of the valve in Roth's species, while in *A. monomastadis* it is located near the center of the valve. The specimen figured by Harlton (1933) as *Amphissites* sp., from the Johns Valley shale, seems to be closely related to this species.

Type.—Holotype, Columbia Univ. Micropaleontological Collection.

Family GLYPTOPLEURIDAE Girty, 1910

Genus GLYPTOPLEURA Girty, 1910

GLYPTOPLEURA SCHIZOPLEURA
Coryell and Sohn, n. sp.
Plate 69, figure 11

Carapace subrectangular in lateral view; dorsal and ventral margins straight and subparallel; posterior margin is more broadly curved than the anterior. Dorsal view wedge-shaped, thinning posteriorly; greatest thickness below midheight. Subcentral pit minute, slightly above and posterior to the center. Carapace thick shelled, strongly ribbed; above the medial rib occur two nearly parallel ribs that unite posteriorly, and form concentric curves near the anterior margin, returning below the midrib to their posterior union. The outermost rib bifurcates ventrally into two ribs that merge again posteriorly. A marginal rib is present. Minute riblets occur in the interrib spaces above and below the anterior part of the medial rib.

Length, 0.65 mm; height, 0.36 mm.

Remarks.—This species differs from *Glyptopleura menardensis* Harlton in that two dorsal ribs are concentric anteriorly and unite with two ventral ribs, in the bifurcation of the lower ventral rib, and in the presence of anterior medial riblets.

Type.—Holotype, Columbia Univ. Micropaleontological Collection.

Superfamily CYPRIDACEA Dana, 1852

Family HEALDIIDAE Harlton, 1933

Genus HEALDIA Roundy, 1926

HEALDIA SIMPLEX Roundy, 1926
Plate 69, figure 12

This species is represented by a few specimens secured from the samples studied.

HEALDIA BLUEFIELDANA
Coryell and Sohn, n. sp.
Plate 69, figure 13

Dorsal margin curved, with a gentle posterior slope and a slight acumination near the middle; ventral margin nearly straight, curving gradually into the rounded ends. Greatest extension at midheight; greatest height near center; anterior half higher than posterior. Greatest thickness near the crested, steep posterior surface slope. Left valve larger, apparently overlapping the right along the entire margin. Surface is smooth, except for the crested posterior ridge.

Length, 0.55 mm; height, 0.35 mm; width, 0.20 mm.

Holotype, Columbia Univ. Micropaleontological collection.

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JOURNAL OF PALEONTOLOGY, VOL. 12, NO. 6, PP. 604–609, NOVEMBER, 1938

A CATALOGUE OF FORAMINIFERA

BROOKS F. ELLIS

The most effective work with Foraminifera requires ready access to the literature, and especially to those portions of it in which genera and species have been described and figured. As all workers in this field know, complete files of the literature do not exist, even in the largest libraries. In addition, descriptions have been written in at least a dozen different languages. The literature is further confused by the fact that many authors have disregarded the rules of nomenclature. This situation has prevailed over more than a century and a half and has resulted in almost endless duplication, misinterpretation and general chaos.

In view of these conditions, micropaleontologists have long realized the need for a compilation which would contain the original descriptions and figures of all genera and species of Foraminifera, and an organization to keep it up to date and to act as a depository of types. Practical difficulties, however, have been so great heretofore, that the undertaking was considered impossible.

Several years ago I laid the groundwork for such an undertaking, assisted by Miss A. R. Messina, by compiling an index to the literature of Foraminifera. New York University and the American Museum of Natural History lent their aid to the furtherance of the task. Progress was very slow, however, until a large staff to carry out the routine research was secured through the help of the Civil Works Administration. Since that time rapid strides have been made and now the undertaking is practically completed. The later phases of the work have been carried out with the aid of the Works Progress Administration.

ACCURACY

Method of Operation.—The accuracy of a compilation of this size and complexity depends on the character of the personnel and the system of handling the materials. Inasmuch as the undertaking was started some ten years ago and expanded gradually, there was ample time to develop an effective method of operation before it became a sizable project. This method was revised and improved as the undertaking grew in size until it attained the form depicted in the accompanying figure. Its complexity is only apparent, as a careful inspection will show. The number of checks performed indicates the thoroughness with which each step of the process is inspected.

An outstanding feature is the method of reproducing illustrations. When figures are photographed and then photoengraved, fine details are lost. In order to overcome this difficulty all figures, except those of thin sections, are drawn on a base to which form and line have been transferred by a combination of photography and tracing. Carbon pencils are used throughout the process, and the figures thus produced are not only accurate but also retain their sharpness and detail even after they have been engraved.

Personnel.—The personnel consists of 130 men and women, grouped in 13 different departments. Each group is responsible for a single phase of the undertaking and is staffed by workers trained and experienced in that particular field. The research groups are composed of geologists, biologists, and translators. The latter enable the project to handle materials written in any modern civilized language.

NATURE OF THE CATALOGUE

Point of View.—In systematizing the original data to be included in this catalogue, a strictly objective point of view has been maintained. Typographical and

printers' errors have been corrected. Corrections of other obvious errors have been given in brackets or footnotes, but the original has not been altered. In all cases, therefore, the reader may be perfectly confident that he has before him an exact transcript of the original.

in each species unit, as well as an exact reproduction of the type figures. In addition, type and all subsequent references will be included. Descriptions written in a foreign language other than German, French or Italian will be accompanied by a translation.

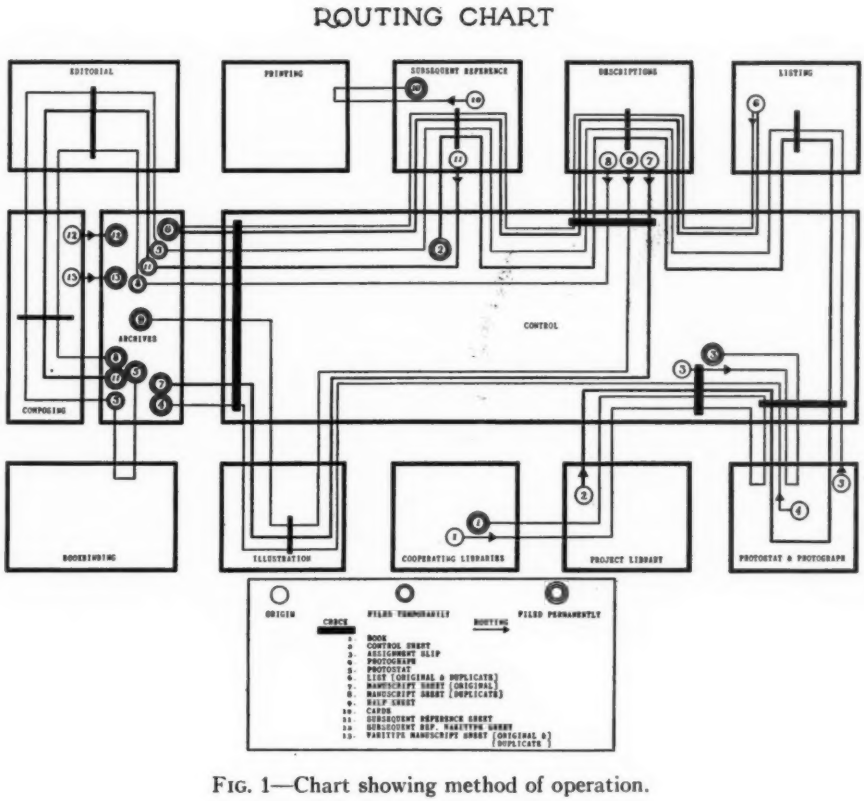

FIG. 1—Chart showing method of operation.

Contents.—The catalogue will contain 30,000 pages of text and illustrative material dealing with some 15,000 genera and species. These are treated as separate units. Each generic unit will contain the type reference, a verbatim transcript of the original description, type species where designated by the original authors, and a chronologically arranged list of subsequent references up to 1938. The type reference and a verbatim transcript of the original description are to be given

Arrangement.—These materials are to be arranged alphabetically by genera and within each genus alphabetically by species. Subspecies and varieties will, of course, be filed with the species to which they belong. The table of contents is to be arranged in the same manner and will be cross-indexed to indicate synonymy. In order to permit rearrangement and to provide for the insertion of newly published genera and species a special loose-leaf post binder has been developed. The

catalogue, as issued, will consist of thirty volumes bound in these covers.

SUPPORTING MATERIALS

A vast amount of supplementary material has been assembled as a by-product of this compilation. The value of these supporting data was realized long ago, and they have been classified and filed with as much care as any portion of the catalogue. They are, of course, far too extensive to be published. Instead, they will be kept in a central clearing-house where they will be readily available to workers in this field.

Photostats.—One of the most valuable of these supporting materials is the library of photostats. From the inception of this work photostatic copies have been made of all articles on Foraminifera that have passed through the organization. These are now being bound in book form and will constitute the source library of the central clearing-house. This library, which will eventually contain photostats of all articles on Foraminifera, will be linked to the published catalogue through type and subsequent references. Positive copies of any portion of it may be obtained by anyone desiring them.

Photographs of Plates.—In addition to photostats, photographic negatives and prints are being made of all published plates and figures of Foraminifera. When completed this file will be a valuable source of information. While the published catalogue will contain only the original figures for each species, this file of photographs will contain all figures of all species. Any of these can be located readily through the subsequent references given in the catalogue and copies can be had by anyone desiring them.

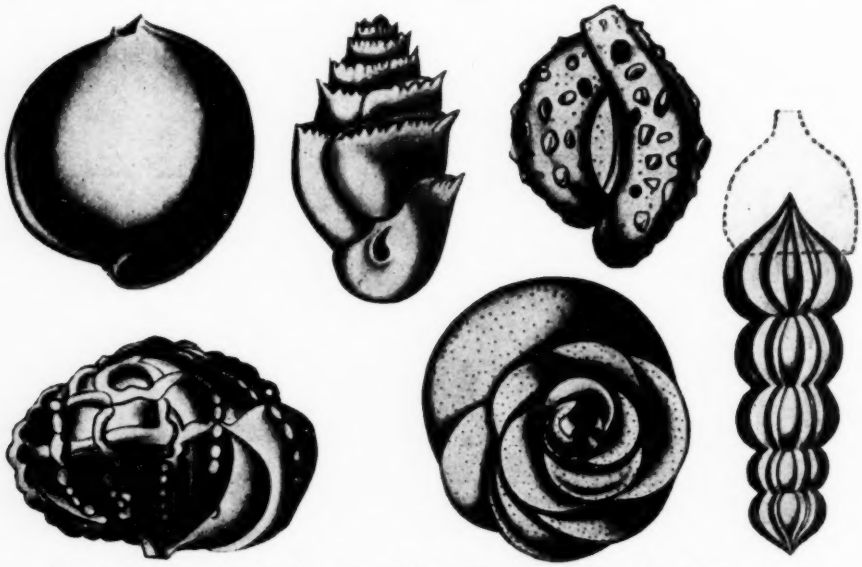

FIG. 2—Representative drawings. (The central upper figure should have been oriented in inverted position).

Indices.—An extensive system of card indices has been developed. One is an index to the genera and species cross-referenced to show synonymy. Another is arranged to indicate geographic and geologic distribution. A third shows depository of type specimens. In addition there is a complete bibliography and a general subject index.

THE PERMANENT ORGANIZATION

The need for a permanent organization to care for these supporting materials as well as to keep the published catalogue up to date is at once apparent. Such an organization should not only act as a clearing-house for current literature, but also as a depository for types and faunas. In addition, it should be staffed and equipped to supply information from the source library and indices on request, and to provide visiting scientists with space, equipment, and aid in carrying on their researches. Moreover, it should be the

19 11a 11b

'CRISTELLARIA LATIFRONS Brady, 1884

TYPE REFERENCE: Brady, H. B., *Report on the foraminifera dredged by H.M.S. Challenger, during the years 1873-1876.* Rept. Challenger Expedition, London, England, 1884, Zool., pt. 22, vol. 9, p. 544.

TYPE FIGURE: Ibid., pl. 68, fig. 19; pl. 113, fig. 11. Pl. 68, fig. 19, X 50; pl. 113, fig. 11a, lateral aspect; b, front peripheral aspect, X 35.

TYPE DESCRIPTION: "Test spiral, elongate, trihedral, broadest near the middle and tapering towards the ends; dorsal margin acutely angular and carinate; ventral face broad, oval, somewhat curved, and with partially carinate lateral edges; oral extremity pointed, aboral end thin and carinate. Early segments small and involute; later chambers long, narrow, slightly curved, obliquely set or almost erect. Length, 1/18th inch. (1.4 mm.).

"This very striking and beautiful variety belongs to the same section of the genus as *Cristellaria arcuata*, d'Orbigny, and *Cristellaria acutauricularis* (F. and M.). It is distinguished by its broad front, its long, narrow, suberect chambers, and the more or less carinate development of the three salient angles of the test. These characters are best exemplified by the specimen figured in Pl. CXIII."

TYPE LEVEL: Recent. Exceedingly rare.

TYPE LOCALITY: Not designated. Localities given: Off the west coast of New Zealand, 275 fathoms, and off Culebra Island, West Indies, 390 fathoms.

TYPE SPECIMEN: Depository not given.

FIG. 3—A typical species unit as it will appear in the catalogue. *Original names have been retained, and synonymy will be indicated by a cross-referenced index. Subsequent references to the species under its original name are given on the reverse side of the sheet.

policy of such an organization to maintain a strictly objective attitude and to supply information and service uncolored by bias or opinion.

As the next logical step in the development of this undertaking, therefore, the quarters should be in one of the world's great centers of communication.

The catalogue, which will be distributed by the Museum, is nearly complete. Practically all of the materials have been checked and edited and are now under-

CRISTELLARIA LATIFRONS Brady, 1884

SUBSEQUENT REFERENCES:

1888–Mariani, E., Soc. Ital. Sci. Nat., Atti, Milano, Italia, vol. 31, fasc. 1, p. 115–116.
1891–Dervieux, E., Soc. Geol. Ital., Boll., Roma, Italia, vol. 10, fasc. 1, p. 606.
1894–Chapman, F., Roy. Micr. Soc., Jour., London, England, art. 9, pt. 7, p. 652, pl. 10, fig. 8a, b.
1894–Fornasini, C., R. Accad. Sci. Istituto Bologna, Mem. Sci. Nat., Bologna, Italia, ser. 5, tomo 4, p. 130, pl. 2, fig. 36, 36a.
1895–De Amicis, G. A., Natur. Siciliano, Giorn. Sci. Nat., Palermo, Italia, anno 14, no. 6–7, p. 105–106.
1898–Silvestri, A., Pont. Accad. Nuovi Lincei, Mem., Roma, Italia, vol. 15, p. 181.
1899–Flint, J. M., U. S. Nat. Mus., Washington, D. C., U. S. A., Ann. Rept. (1897), pt. 1, p. 316, pl. 63, fig. 3.
1900–Silvestri, A., Pont. Accad. Nuovi Lincei, Mem., Roma, Italia, vol. 17, p. 269.
1906–Chapman, F., New Zealand Inst., Trans. Proc., Wellington, New Zealand, vol. 38, pt. 2, art. 17, p. 97.
1913–Cushman, J. A., U. S. Nat. Mus., Bull., Washington, D. C., U. S. A., no. 71, pt. 3, p. 78, pl. 38, fig. 2a, b.
1917–Chapman, F., Geol. Surv. Western Australia, Bull., Perth, Australia, no. 72, ser. 6, art. 11, p. 37, pl. 12, fig. 122.
1917–Halkyard, E., Manchester Lit. Philos. Soc., Mem. Proc., Manchester, England, vol. 62, pt. 2, p. 92.
1918–Sidebottom, H., Roy. Micr. Soc., Jour., London, England, art. 4, pt. 2, p. 140.
1920–Cushman, J. A., U. S. Nat. Mus., Proc., Washington, D. C., U. S. A., no. 2302, vol. 56 (1919), p. 617.
1921–Cushman, J. A., U. S. Nat. Mus., Bull., Washington, D. C., U. S. A., no. 100, vol. 4, p. 254.
1923–Cushman, J. A., U. S. Nat. Mus., Bull., Washington, D. C., U. S. A., p. 126.
1930–Macfayden, W. A., Geol. Surv. Egypt, Cairo, Egypt, p. 81.
1932–Nuttall, W. L. F., Jour. Pal., Menasha, Wis., U. S. A., vol. 6, no. 1, p. 11, pl. 2, fig. 11.

FIG. 4—Reverse side of species unit.

American Museum of Natural History plans to establish such an organization as a regular department of that institution. The advantages of this are permanency, library facilities, and ideal location. With respect to location, it is to be remembered that the work of the department must necessarily be international in scope, and for this reason its headgoing an additional check by a group of micropaleontologists. More than a third of the catalogue has been set up on composing machines in preparation for reproduction by photo-offset.

It is still too early to set a price or date of publication, but certain generalizations can be made. The price will be kept as low as possible so that the catalogue

will be within the means of individuals as well as institutions and companies. The date of publication will depend on the length of time required to print the compilation. It is believed that most of this job can be done within the next year and a half.

Data for new genera and species published after 1938 will be issued yearly as supplementary sheets. For these and service it will be necessary to charge a nominal annual fee.

BROOKS F. ELLIS, NEW YORK UNIVERSITY, NEW YORK CITY. MANUSCRIPT RECEIVED BY THE EDITOR, JULY 11, 1938.

SOCIETY RECORDS AND ACTIVITIES

SOCIETY OF ECONOMIC PALEONTOLOGISTS AND MINERALOGISTS

A Division of the American Association of Petroleum Geologists

CONSTITUTION

ARTICLE I. NAME

The Society shall be known as the Society of Economic Paleontologists and Mineralogists.

ARTICLE II. OBJECT

The object of the Society shall be to promote the science of stratigraphy through research in paleontology and sedimentary petrology, especially as these relate to development of knowledge of the geology of petroleum.

ARTICLE III. MEMBERSHIP

1. The Society shall be composed of active members, associate members, honorary members, correspondents, and patrons.

2. Active members shall be persons engaged in paleontologic, petrographic, or stratigraphic studies as applied to the geology of petroleum and who have been duly elected members or associate members in the American Association of Petroleum Geologists.

Active members alone shall be known as members.

3. Associate members shall be known as associates. Any person engaged in paleontologic, petrologic or stratigraphic studies that have application to the geology of petroleum is eligible for associate membership. Associates shall enjoy all the privileges of membership in the Society, save that they shall not hold office, sign applications for membership, or vote.

4. Honorary members shall be persons of distinguished achievement whose contributions to paleontology, petrology, and stratigraphy have an application to the geology of petroleum.

5. Correspondents shall be persons not resident in North America who have made distinctive contributions to paleontology, petrology, and stratigraphy that have application to the geology of petroleum.

6. Patrons shall be persons who have bestowed important favors on the Society.

ARTICLE IV. OFFICERS

1. Executive authority of the Society is vested in a council consisting of five members duly elected officers, as follows: president, vice-president, secretary-treasurer, and the two most recently retired past-presidents.

2. The president shall discharge the usual duties of a presiding officer at all meetings of the Society and council.

3. The vice-president shall assume the duties of the president in case of his absence.

In the event of the absence from the meetings of both president and vice-president the duties of presiding officer shall fall upon one of the other members of the council in the following order: most recent past-president, second most recent past-president, secretary-treasurer.

4. The secretary-treasurer shall keep record of the proceedings of the Society, and a complete list of the membership. He shall attend to the preparation and mailing of notices and other materials required in the business of the Society. The secretary-treasurer shall have custody of all funds of the Society, and shall keep a detailed account of receipts and disbursements.

5. The council shall consider all nominations for membership and pass on the qualifications of the applicants; shall have control and management of the affairs and funds of the Society; shall determine the manner of publication and pass on the material presented for publication; and shall designate the place of the annual meeting. They are empowered to establish a business headquarters for the Society and to employ such persons as are needed to conduct the business of the Society.

6. Elections shall be held annually to select a president, vice-president, and secretary-treasurer.

ARTICLE V. MEETINGS

1. The Society shall hold at least one stated meeting a year, which shall be designated as the annual meeting. The time and

place of the annual meeting shall be designated by the council, but in general, it shall be held in connection with the annual meeting of the American Association of Petroleum Geologists.

2. The annual meeting shall be devoted to the reading and discussion of scientific papers, to the transaction of Society business, and other appropriate functions.

3. The program for the annual meeting shall be arranged by the council, or under its directions.

ARTICLE VI. SECTIONS

Local sections of the Society may be established according to provisions of the By-Laws.

ARTICLE VII. AMENDMENTS

1. The Constitution may be amended at any annual business meeting by two-thirds vote of the members present, or by mail ballot sent to the members, in which case two-thirds of the returned ballots received in sixty days after mailing must approve the amendment in order to make it effective. Any proposed changes to the Constitution must first have the approval of the council.

By-Laws

ARTICLE I. DUES

1. The fiscal year of the Society shall correspond with the calendar year.

2. The annual dues of members and associates of the Society who desire only the *Journal of Paleontology* shall be six dollars ($6.00). The annual dues of members and associates who desire only the *Journal of Sedimentary Petrology* shall be three dollars ($3.00). Members and associates may receive both Journals by the payment of eight dollars ($8.00). Members of the Society, who are also members of the Paleontological Society and receive the *Journal of Paleontology* through the latter society, may retain membership in the Society of Economic Paleontologists and Mineralogists by the payment of one dollar ($1.00) per year dues. The annual dues are payable in advance on the first day of each calendar year. A bill shall be mailed to each member and associate before January first of each year, stating the amount of annual dues and the penalty and conditions for default of payment. Members and associates who shall fail to pay their annual dues by April first shall not receive further copies of either *Journal*, nor shall they be privileged to buy Society publications at special discounts made to the membership, until such arrears are met.

3. Honorary members, correspondents, and patrons may be nominated by a vote of four members of the council and such nomination shall be submitted to the members by mail ballot. Providing eighty per cent or more of the returned ballots are favorable, the nominee shall be declared elected. Honorary members, correspondents, and patrons shall not be required to pay annual dues.

ARTICLE II. DUTIES AND PRIVILEGES OF MEMBERS

1. Members and associate members dropped for non-payment of dues may apply to the council for reinstatement, and, providing settlement is made of any outstanding indebtedness for publications and other charges approved by the council, may be reinstated by vote of four members of the council.

2. Members shall be eligible to receive publications of the Society at special subscription rates as authorized by the council or as provided in these By-Laws.

3. The council is authorized to transmit without charge such publications as it may direct to honorary members, correspondents, and patrons.

4. Only active members shall have the right to vote in electing officers and in transacting the business of the Society.

ARTICLE III. OFFICERS

1. Nominations for officers shall be made in the following manner. Prior to September 1 of each year, the president shall designate two nominating committees, instructing each committee to submit nominations for president, vice-president, and secretary-treasurer, these nominations to be in the secretary's hands before September 15. If desired, the same person may be nominated by the two committees for the office of secretary-treasurer, but nominations for president and vice-president shall not include the name of the same person on the two slates. The nomina-

tions of the first committee to file its report will have precedence in case of overlapping nominations and the other committee shall then be requested to change its nomination.

2. Ballots containing the nominations for officers, alphabetically arranged under each office, shall be prepared by the secretary-treasurer and mailed to each member of the Society on or before October 1. Neither the ballot nor the enclosing envelope need contain the name of the voting member, but an outer envelope that contains the sealed ballot must bear the name of the voting member. The returned ballots received by the secretary-treasurer on or before December 1 shall be counted by him, and if requested, shall be submitted to recount by the council. A plurality of the votes received for any office constitutes election.

ARTICLE IV. PUBLICATIONS

1. The council is authorized and directed to make such arrangements for editorial preparation of manuscripts, publication, distribution, general business management of publications, and all other proper matters connected with efficient handling of publications of the Society not provided for in the Constitution as it shall deem desirable in the Society's interest. This includes designation of an editor or editors, who shall serve at the pleasure of the council in the formulation of publication policies, including the making of contracts for printing and engraving, entering into agreements with other scientific societies for joint publication, and acceptance of advertising at determined rates. The council shall supply the editor or editors with a publication budget at the annual meeting of the Society. This budget may be expanded or contracted at later date by vote of the council. In this matter, and in other matters affecting publication policy, the editor or editors will be given the same vote as members of the council.

2. The *Journal of Paleontology* and the *Journal of Sedimentary Petrology* are designated as official publications of the Society. The council is not authorized to initiate and publish other periodicals.

3. A publication fund may be established consisting of an assignment of a portion of dues as designated by the council, and such donations as are specifically made for that purpose. The council is authorized to provide special publications from this fund as may be deemed desirable, and to fix terms for sale or other distribution of these publications.

ARTICLE V. FINANCIAL METHODS

1. No financial obligations shall be contracted without express sanction of the Society or council, but all ordinary incidental running expenses have sanction without special action.

2. Statements of accounts charged to the Society, other than miscellaneous running expenses, shall be approved by the president before the secretary-treasurer pays the amount out of funds of the Society not otherwise appropriated, and the receipted bill shall be held as the secretary-treasurer's voucher.

3. The secretary-treasurer shall have charge of the financial affairs of the Society and shall annually submit reports as secretary-treasurer covering the fiscal year. He shall receive all funds of the Society, and, under the direction of the council, shall disburse all funds of the Society. He shall cause an audit to be prepared annually by a public accountant at the expense of the Society. He shall give a bond, and shall cause to be bonded all employees to whom authority may be delegated to handle Society funds. The amount of such bonds shall be set by the council and the expense shall be borne by the Society. The funds of the Society shall be disbursed by check as authorized by the council.

ARTICLE VI. BUSINESS REPRESENTATIVES

1. The president and the secretary-treasurer of the Society shall act as business representatives of the Society in the business committee of the American Association of Petroleum Geologists. These representatives shall conduct such business with the executive committee of the Association as is of mutual interest to the Society and the Association in the interims between the annual meetings of the Society and the Association. Approval of the action of these representatives on the part

of the Society during any year is reserved to the council in session at the annual meeting at the close of that year. Questions remaining unsettled between the representatives of the Society and the executive committee of the Association shall be considered in a joint meeting of the council of the Society or its authorized representatives and the executive committee of the Association at the annual meeting of the Association at the close of the interim period during which such questions have arisen.

ARTICLE VII. SECTIONS

1. The establishment of local sections of the Society may be authorized by unanimous vote of the council approving a petition for such establishment signed by ten members of the Society. Such local sections may elect officers, conduct meeting, and engage in other scientific activities, but shall not be entitled to special representation in general society affairs.

2. The council is authorized and directed to withdraw the charter of any established local section if there is evidence that it has become inactive.

ARTICLE VIII. AMENDMENTS

1. The By-Laws may be amended at any annual business meeting by two-thirds vote of the members present, or by mail ballot sent to the members, in which case two-thirds of the returned ballots received in sixty days after mailing must approve the amendment in order to make it effective. Any proposed changes to the By-Laws must first have the approval of the council.

Note: The revised Constitution and By-Laws as herein published have been approved by nearly unanimous vote of the Society.

Verlag von Gebruder Borntraeger in Berlin W 35 Deutschland

Fortschritte der Paläontologie. Unter Mitarbeit zahlreicher Fachgenossen herausgegeben von **O. H. Schindewolf**, Berlin.

I. Band: Bericht über die Jahre 1935 und 1936.
Mit 2 Abbildungen. (384 Seiten.) 1937 Geheftet RM 29.60

Die „Fortschritte der Paläontologie", eine periodisch erscheinende Bandfolge, setzen sich die Aufgabe, in Form von kritischen Sammelberichten die Hauptergebnisse darzustellen, die während eines Zeitraumes von zwei Jahren auf den Gebieten der Paläozoologie und der Paläobotanik erzielt worden sind. Der vorliegende erste Band verarbeitet die Literatur der Jahre 1935/1936 und liefert ein übersichtliches Bild über den gegenwärtigen Stand der paläontologischen Forschung.

Paläontologie, Entwicklungs- und Vererbungslehre von Professor **Dr. O. H. Schindewolf.** Mit 34 Textabbildungen. (VII u. 108 S.) 1936 Geheftet RM 5.20

Diese Schrift führt auf theoretischer und praktisch-palaeontologischer Grundlage zu einer Neuorientierung der Entwicklungslehre. Durch eine kritische Untersuchung der Faktorenfrage und Überwindung des Lamarckismus dient sie einer Verständigung zwischen den seither getrennte Wege gehenden Disziplinen der Entwicklungs- und Vererbungslehre.

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JOURNAL OF PALEONTOLOGY

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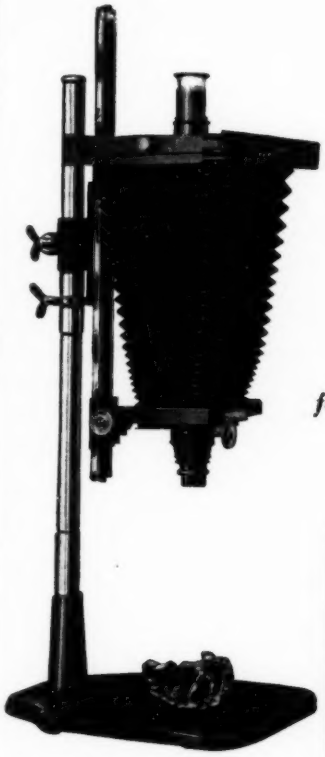

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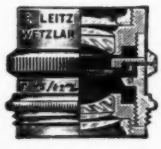

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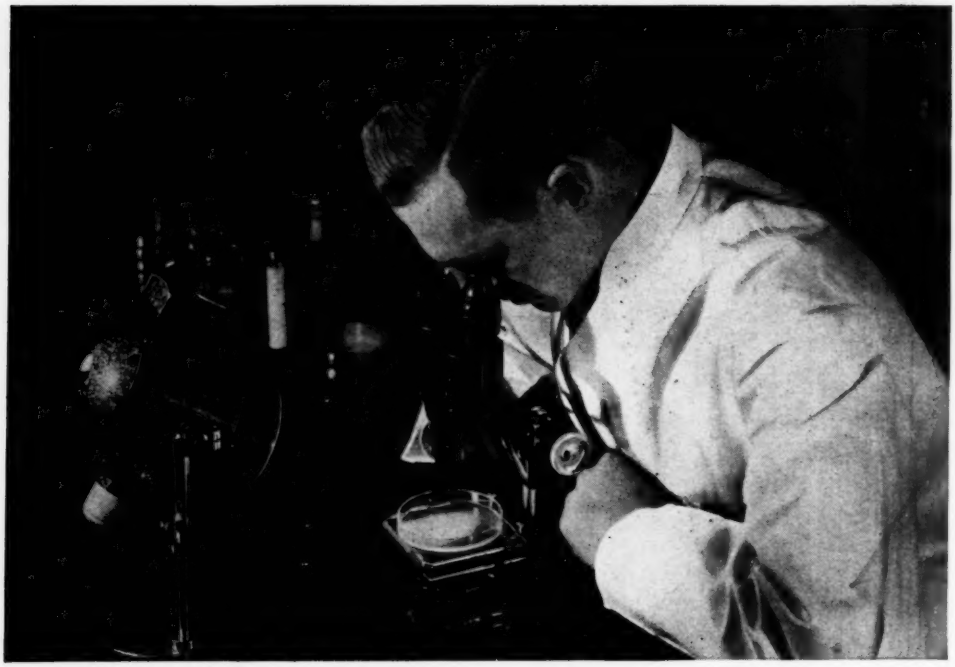

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